SCENE FROM PHOTOPLAY, "MADELINE'S REBELLION"
Courtesy of *Thomas A. Edison, Inc., Orange, N. J.*

Cyclopedia
of
Motion-Picture Work

A General Reference Work on

THE OPTICAL LANTERN, MOTION HEAD, SPECIFIC PROJECTING MACHINES, TALKING PICTURES, COLOR MOTOGRAPHY, FIXED CAMERA PHOTOGRAPHY, MOTOGRAPHY, PHOTO-PLAYS, MOTION-PICTURE THEATER, MANAGEMENT AND OPERATION, AUDIENCE, PROGRAM, ETC.

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Illustrated with Over Three Hundred Engravings

TWO VOLUMES

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Foreword

TWENTY years ago the motion picture was a child's toy. Today it is the basis of a business giving profitable employment to thousands of workers, offering amusement and education to millions of people, and involving an investment of capital that places it among the world's great industries.

¶ The motion-picture maker sets up his whirring camera in the wilds and the crowded city alike. He records the downfall of kings and the inauguration of presidents, the horrors of great disasters and the deeds of popular heroes; he spreads before us in moving panorama all that is interesting in nature and in man's work, in drama and in real life. Every large city has its motion-picture factory, and every village its motion-picture theater. Into communities too small to support a theater regularly comes the traveling exhibitor with his portable outfit, and shows in town hall, church, or country school house.

¶ For so important an industry a book of reference and instruction is more than merely justified; it is demanded. The motion-picture field is broadening day by day; the details of the business are becoming more multitudinous with each advance. The worker in one branch of activity must have some knowledge of all the branches to be able to get the best results in his own work. This Cyclopedia of Motion-Picture Work is the first compilation to cover adequately the entire field.

¶ The Art of the motion picture comprises two principal industries: the manufacturing, and the exhibiting, of film pictures. Both of these fields are covered by this Cyclopedia. The worker in either will be deeply interested in the detail and technique of the other, and will profit by that broader knowledge. The beginner requires a complete knowledge of both branches to fit himself for work in either branch.

¶ The drawings, diagrams, and photographs incorporated into the Cyclopedia have been prepared especially for this work; and their instructive value is as great as that of the text itself. They have been used to illustrate and expand the text, and not as a medium around which to build the text. Both drawings and diagrams have been rendered as simply as was compatible with their correctness, with a view to making them as nearly as possible self-explanatory.

¶ The Cyclopedia is a compilation of many of the most valuable Instruction Papers of the American School of Correspondence, and the method adopted in its preparation is that which this School has developed and employed so successfully for many years. This method is not an experiment, but has stood the severest of all tests—that of practical use—which has demonstrated it to be the best yet devised for the education of the busy man.

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SCENE FROM "A PRIESTESS OF CARTHAGE," BY GAUMONT

This Scene is from a portion of the Film Showing the Religious Services of the Time

Courtesy of the *Kleine Optical Co., Chicago*

PHOTOGRAPHY

THEORY

The making of photographs may be divided into three very general or theoretical steps: *First,* producing an image of the scene or object of which it is desired to make a photograph. *Second,* recording the image in permanent form. *Third,* copying, multiplying, or reproducing the image into as many finished photographs as may be desired.

Any of these steps may be accomplished in any of several ways by the photographer, according to the results which he desires to attain, or according to the limitations of the apparatus which he has available. Thus, images usually are formed for photography by means of a lens; but if the photographer has no lens, or arbitrarily decides not to use it, he may form an image without it. The image formed being composed of rays of light of different strengths, the second step taken by placing in the image a surface bearing a substance which is sensitive to light and which will be discolored to different degrees by the different strengths of the different rays and by the spots of light formed by them in the image. This second step produces the record of the image, and from it a number of finished photographs may be produced in a manner not altogether unlike the production of several thousand newspapers by a printing press after the typesetters have made ready the printing types and the engravers have made ready the printing picture plates.

MECHANICAL DETAILS

Camera. The camera is a dark box within which the photographer forms the image. The light is admitted to the camera during the making of the photograph, and in most cameras during the preparation for the photograph and the proper adjustment of the camera for forming the desired image.

Pin-hole Image. To understand just how the image is formed in the camera, perform the following experiment:

Take a paper box, white inside, about the size of a shoe box. Remove half of the lid. In the middle of one end of the box, punch a hole with a darning needle, making a hole about $\frac{1}{16}$ inch in diameter, with smooth edges. Place the box in the window, the hole toward the street, and with the half-lid on that part of the top of the box near the street. Draw the shade to the top of the box, and obscure the remainder of the window as well as other windows of the room so that the only light received will be through the small hole in the end of the box—the *pin-hole* as it is termed in photography, Fig. 1. On the inside of the box, at the end opposite the pin-hole, there will

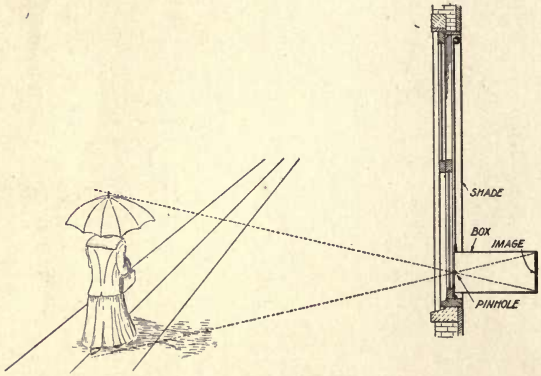


Fig. 1. Pin-hole Image

be formed an image of the objects upon the opposite side of the street. The image may be viewed through the open half of the top of the box, and will be seen a living image, in natural colors, but inverted, its size depending upon the length of the box. Try it with boxes of different lengths, or moving a white card in the box.

Inverted Image. The reason why the image is inverted is shown in Fig. 2, in which the object, the pin-hole, and the image are represented. All rays of light pass in straight lines, and all the light from the top of the tree at the right which gets through the pin-hole passes in a straight line to the bottom of the image at the left; light from the bottom of the tree goes to the top of the image. This is true for every point of the view; hence, the view is inverted in the image.

Now with a lead pencil, enlarge the pin-hole until the pencil can pass through. Note the difference in the image. It is blurred. Each point in the scene makes a spot in the image as large as the hole in the box; yet the image as a whole is brighter. A spectacle lens placed over the hole in the box might make the image sharp, but at this point the pin-hole experiment may be abandoned and the working of the photographer's camera as it is commercially used may be taken up to complete the study of the first step in theory, or the formation of the image in practice.

Buying a Camera. The learner who intends either to make moving pictures after learning still photography, or to make *good* still photographs, must first purchase a tripod camera. Concerning the work of hand cameras, a photographer handling amateur work at a holiday resort is quoted as saying that of more than a

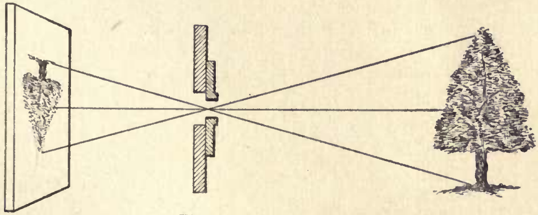


Fig. 2. Inverted Image

thousand negatives developed by him in one summer there were not twenty good pictures and hardly forty good negatives. Only with the tripod camera can the photographer know what he is doing and then operate his camera intelligently and successfully.

The camera purchased for intelligent work must be either 4-inch by 5-inch size, with bellows draw of 12 inches or more, or 5-inch by 7-inch size, with bellows draw of 15 inches or more. Smaller than 4 by 5 is too small for intelligent work by the ambitious amateur, and larger than 5 by 7 is too heavy for amateur work. In either case, the camera should have a single swing, and must have a rising front and holders for glass plates; it may have a convertible rectilinear lens or a more expensive convertible anastigmatic lens, but in either case the lens must be convertible and should be equipped with an iris diaphragm and an automatic shutter. The usefulness of each of these features will appear as the operation of the camera is described. A camera 4 by 5 may be had at a catalogue price of $25.00 or more, and a camera 5 by 7 at $33.00 or more, filling all requirements. Two extra plate-holders should be bought, that six plates may be carried into the field. A tripod and focusing cloth complete the necessary field equipment, with the possible addition of an exposure meter.

Construction of Camera. The body of the camera consists of the back frame, the front frame, and a base. The base connects the back and front frames and upon it the front frame moves as upon a track. Connecting the back and the front is the bellows. The front carries the lens, mounted upon a detachable lens board; the back carries the ground glass or focusing screen, and permits the insertion of one of the plate-holders in such a manner that when the plate-holder is inserted the ground glass is pushed out of its normal position and the glass plate within the holder occupies the position formerly held by the ground glass.

Place the camera in the window as the shoe box was, and open shutter and diaphragm. The shutter is opened by setting its index to "T," or "Time," and operating it with the rubber bulb. The diaphragm is opened by setting its index to the lowest number, probably 8. Extend the bellows until a sharp image is seen upon the ground glass. Look *at* the ground glass, not *through* it. If the back of the camera and the operator's head are covered with the focusing cloth, it will not be necessary to darken the room for this experiment. By moving the camera front to different positions, it will be observed that the image is sharp in only one position. This is the position of focus of the lens.

Lenses. The lens is composed of a barrel carrying the shutter and iris diaphragm in its middle portion and carrying at each end a "lens cell," or metal mount, into which the glasses of the lens are fixed. The glasses may be removed from the lens barrel by unscrewing their mounts from the barrel. Unscrew the front lens cell and extend the bellows until the image upon the ground glass is sharp again. This is the focus for the "back combination," or that cell which still remains in the lens. The bellows is longer, the image is larger. Sometimes the front combination of the lens is of still longer focus than the back combination, giving an image still larger, but with still longer extension of the bellows.

Replace the lens cells. Select in the image a distant object, such as a chimney 500 feet away. Focus sharply upon it by moving

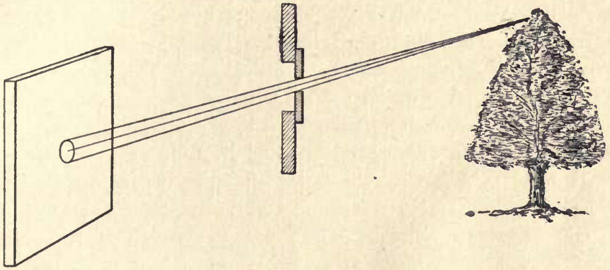


Fig. 3. Pin-hole without Lens

the camera front until the chimney is sharp. Note a near object, a house or tree within 50 feet; it is not sharp. To focus sharply upon the near object, it is necessary to extend the bellows slightly. Now the distant object is not sharp. Try to place the focus between the two; then reduce the iris diaphragm to 32 or even 64. Now both distant and near objects are sharp.

Remove both lens cells. Shut the iris diaphragm as close as it will move. Look upon the ground glass; the image of the shoe box is there. Move the bellows to different lengths; the size of the

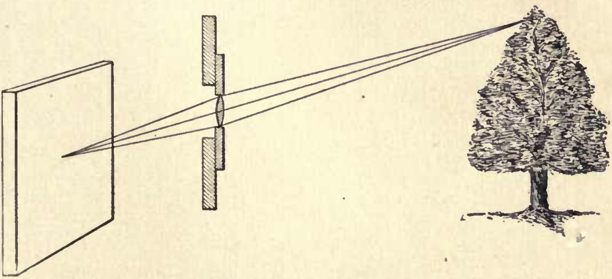


Fig. 4. Pin-hole with Lens

pin-hole image is changed but it is in as good focus in one place as another. The pin-hole image has no definite length, and everything, near and far, is in focus. Replace the lens cells. With the diaphragm still at its smallest size, the lens makes the image sharper, but a position may be found at which everything seems to be in focus, both near and far objects. This is called the *condition of universal focus.*

Focal Length. The distance from the ground glass to the center of the lens when the image is in focus upon the glass, is called the focal length of the lens, and usually is expressed in inches. The focal length of the two combinations or cells of the lens when used together is shorter than the focal length of either of them. With a 5 by 7 lens, the complete lens should have a focal length of 7 inches or a little more; each of the combinations alone should be about 12 inches, or one of them about 11 and the other about 14 inches.

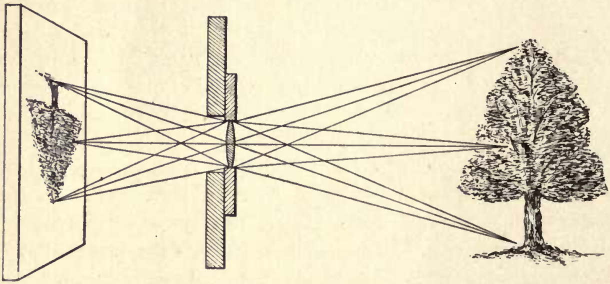


Fig. 5. Lens Image

Figs. 3 and 4 show the action of the lens. The glass of the lens bends the rays of light, which proceed from a point in the subject until they reach the lens and then are bent by the lens to approach until again they meet in a point, making a sharper spot of light on the ground glass in Fig. 4 with the lens than in Fig. 3 where the pin-hole without the lens is shown. This is true of all points of the subject, as shown in Fig. 5.

The distance from the lens to the place where the ray again comes to a point depends upon the strength of the lens in bending the rays, and this distance is the focal length of the lens. In Fig. 6 the back lens cell alone bends the light to bring it to a focus; while in Fig. 7 both front and back lens cells bend the light, one after the other, bending it to a much greater extent, bringing it to a focus in a shorter distance, giving a shorter focus or shorter lens length, and producing of course a smaller image on the ground glass.

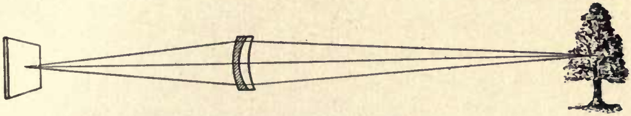


Fig. 6. Long-Focus Lens

Measuring Length. Without a camera, a lens may be measured approximately by focusing the image of the sun upon any convenient surface, such as a small card, then measuring with a ruler the distance from the middle of the lens barrel to the card. With a camera, focus upon a very distant object, and measure from the middle of the lens barrel to the ground glass. A more accurate method, where a camera of sufficiently long bellows is available, is to focus upon any close object until the image on the ground glass is exactly the size of the object. Measure the distance between the object and the ground glass and divide by four. To make this measurement conveniently, cut two slips of paper of equal length and attach one to the ground glass and the other to the glass of the window. Place the camera on a table where it may slide toward the window to change the size of the image. Use the largest diaphragm opening. When the edges of the image of the slip of paper are sharp and when the image on the ground glass and the slip of paper on the ground glass are of the same length, the distance between the object and the image will be four times the focal length of the lens.

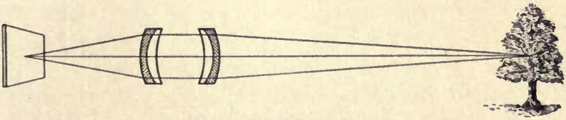


Fig. 7. Short-Focus Lens

Position of Diaphragm Opening. The influence upon the image of the diaphragm opening, or "stop," and of its position with reference to the lens is shown in Figs. 8, 9, and 10. In each of these figures, there are shown a photographic subject composed of straight lines, a lens, a stop opening, and an image of the subject formed by the lens through the diaphragm. In each figure, the subject and the image are shown in a front view, while the lens and diaphragm

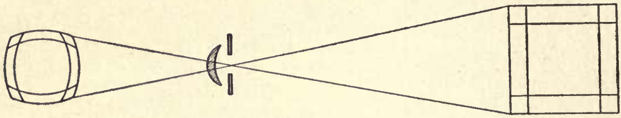


Fig. 8. Barrel Distortion

are shown in side view, or rather in sectional view as though cut through the middle.

In Fig. 8, the diaphragm opening is in front of the lens, between the lens and the subject to be photographed. The result is a bending of all the straight lines of the image, drawing the ends of the lines toward the middle line of the image, both horizontally and vertically. This form of distortion is called *barrel distortion.* In Fig. 9, the diaphragm opening is behind the lens, between the lens and the image. This results in bending the lines of the image in the opposite direction, and produces what is called a *pin-cushion distortion.* In Fig. 10, a double lens is shown, the glasses of the lens being divided into two cells with the diaphragm or stop between them. With such an arrangement the pin-cushion distortion of the front lens cell is just balanced by the barrel distortion of the back lens cell, and the resulting image has all its lines straight. Such a lens is called a *rectilinear lens.* To avoid distortion, the diaphragm

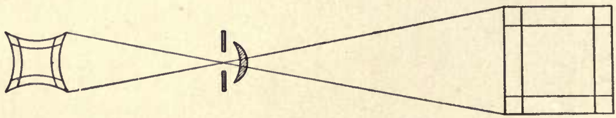


Fig. 9. Pin-cushion Distortion

must be placed between the two cells at the proper distance from both. Of the two forms of distortion shown in Figs. 8 and 9, the barrel distortion is the less objectionable, and when a single lens is used, it should be placed in the back end of the lens tube, even though it be the front cell of the complete lens. The single lens serves satisfactorily for landscape and portrait work, in either of which it may be said there are no straight lines In photographing

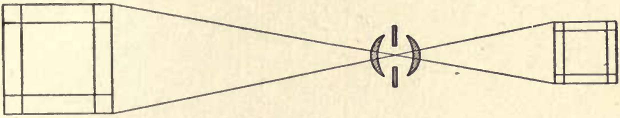


Fig. 10. Rectilinear Lens

architectural subjects, where the straight lines of the sides of buildings are near the edge of the plate, and in interiors, only the rectilinear lens may be used if passable results are desired.

Focusing. Bringing the desired image into focus is controlled by the position of the ground glass at the proper distance from the lens, and also by the size of the opening in the diaphragm or stop. Every point in the image is formed by a mass of light rays which is conical in form, as big as the stop opening at the lens, and tapering down to a point at or near the ground glass. When the exact tip of this cone is upon the surface of the ground glass, the point is in focus and sharp in the image. When the tip of the cone is a little behind or in front of the ground glass, the point is slightly blurred, but if not too much blurred it may be said to be still in focus. The amount of blur depends upon the size of the cone at the place where the ground glass is met. Fig. 11 shows a lens with

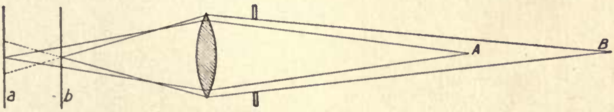


Fig. 11. Lens without Diaphragm Stop

a large stop opening. The point *B* of the subject is in focus at the point *b* of the image; the point *A* of the subject is in focus at the point *a* of the image. With the ground glass at the vertical line, through *a* the point *A* will be sharp and the point *B* will be blurred in the image. With the ground glass at the vertical line, through *b* the point *B* will be sharp in the image and the point *A* will be blurred.

Fig. 12 shows the same system with a smaller stop opening. The cone from the point *A* is smaller where it crosses the vertical line through *b*, hence the blur will be less, and the focus more nearly

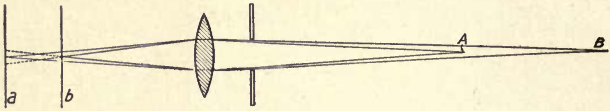


Fig. 12. Lens with Diaphragm Stop

correct. With the ground glass midway between the points *a* and *b*, both will be slightly blurred, but the blur will be less with the smaller top opening, Fig 12 "Depth of field" in an image refers to the distance from the nearest object in focus to the farthest object in focus. With the smaller stop opening, the depth of field is increased.

Spherical Aberration. Lenses ground by machines present spherical surfaces upon both sides, although not of concentric spheres. Such a lens bends a ray of light to a greater degree when the ray passes through the lens near the edge than when the ray passes through the lens near the center. This is illustrated in Fig. 13. By the greater bending, the rays from the object *C* which pass near the edge of the lens are brought to focus on the line *c*, while those through the central portion are brought to focus upon the line *c′*. This defect in the lens is reduced by the use of a lens which is meniscus in form, having one convex and one concave surface, as illustrated in Fig. 14. It is reduced also by the use of a smaller stop opening, as illustrated in Fig. 15.

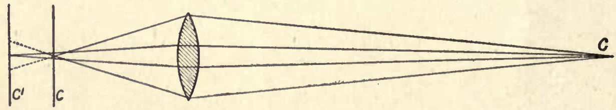


Fig. 13. Spherical Aberration in Convex Lens

Chromatic Aberration. The light rays of different colors are affected to different degrees by the refractive attribute of the glass of the lens. The violet light is bent through a greater angle than the yellow light, and the remaining colors, as well as the ultra-violet rays, are changed in direction through different angles. This produces the effect of bringing the different colors to focus at different distances from the photographic lens of the simplest type, viz, of a single meniscus piece of glass. The principle involved is the same

Fig. 14. Spherical Aberration in Meniscus Lens

as that by which a single ray of white light is separated by a prism into its elementary colors, a band of colored rays being secured by the separation of the single white ray.

The effect in a photographic lens is shown in Fig. 16. The ray of white light from the point *D* of the subject is brought to focus in several different points according to the colors into which the light is separated. The yellow light is brought to focus at the line *d*, while the violet light is brought to focus on the line *d'*. Of all the colors composing white light, yellow affects the eye to the greatest degree and, consequently, in focusing the camera by looking at the image upon the ground glass, the yellow light is appreciated by the eye and the ground glass is brought to that position in which the yellow rays are in focus. At the same time, the red and blue rays are so nearly in focus that they unite to give the appearance of white light in focus upon the screen. When the sensitive plate is placed in the camera, occupying the position of the ground glass, and the light is permitted to fall upon it through the lens,

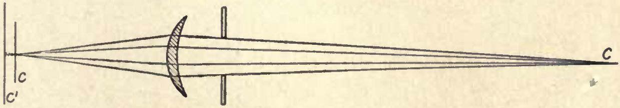


Fig. 15. Spherical Aberration Reduced by Diaphragm Stop

the conditions of appreciation of the light are changed. The sensitive plate is most sensitive to the blue—the violet and the ultra-violet rays—and these are not in focus upon its surface.

Outside of the lens, the remedies for color aberration are to focus through a blue glass, to use a blue ground glass, or to wear blue spectacles. Another method is to know the specific correction for the lens used and to move the ground glass the proper distance toward the lens after focusing upon the yellow image.

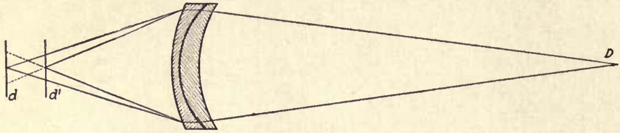


Fig. 16. Chromatic Aberration

Within the lens, the correction may be made by uniting two pieces of glass of different refractive powers, one lens being ground "positive," or thicker in the middle than in the edges, and the other one being ground "negative," or thinner in the middle than in the edges. Two of the surfaces have the same curvature and the two lenses when completed are cemented together, Fig. 17. Even the cheapest classes of lenses are thus made double, except in the smallest sizes and when of short focus. A rectilinear lens, composed of two single lenses, each of which is corrected for chromatic aberration, would present a combination of glasses such as is shown in section in Fig. 18 or Fig. 19.

Astigmatism. The meaning of this word is *with no point.* Its meaning as applied to a photographic lens is that the lens has not the ability to bring to a focus at a point all of the rays proceeding from a point in the subject. Thus a point in the subject becomes something else in the image. The bundle of rays passing from a point in the subject and through the stop opening takes the form

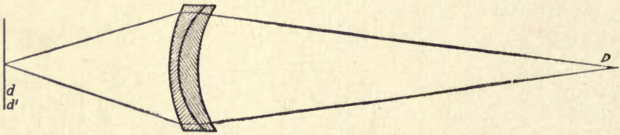


Fig. 17. Achromatic Lens

shown in Fig. 20. The best focus is obtained by placing the ground glass at the line *b*, where the point takes the form of a cross. When the ground glass is at the line *a* nearer the lens, the point takes the form of a short radial line, or ellipse, with its longer axis radial from the center of the image; when the ground glass is at the line *c* farther from the lens, the point takes the form of a short arc about the center

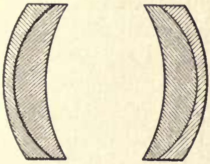


Fig. 18.

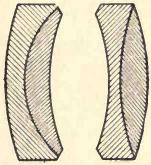


Fig. 19.

Achromatic Rectilinear Lenses

of the image, or of an approximate ellipse of which the shorter axis is radial and the longer axis is an arc instead of a straight line.

The remedy for astigmatism lies in the construction of the lens, and lenses which are corrected for astigmatism are called

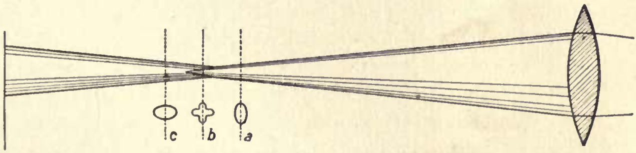


Fig. 20. Bundle of Rays with Astigmatism

anastigmats. Two, three, four, and even five pieces of glass are used sometimes in producing single lenses free from astigmatism, chromatism, and spherical aberration. Fig. 21 shows a single lens

Fig. 21.

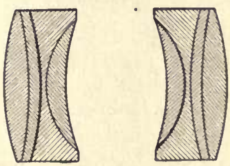


Fig. 22.

Anastigmatic Lens Combinations

of four glasses. Fig. 22 shows the glasses of a double, or rectilinear, lens of two single lenses having eight glasses in all.

The art of the lens maker is a delicate one. A lens should be bought and used by the photographer, and not tampered with.

A good lens should be kept in a dust-proof case when not in use. It may be brushed with a soft camel's-hair brush and wiped with soft clean tissue paper to remove dust—not a cotton or silk rag, which may carry grains of grit to scratch the surface of the glass.

Shutters. When the camera is prepared for exposing a plate to an image, the lens stands as a window in the front of the camera. The purpose of the shutter is to close the lens window until the moment for exposure, then to open the lens and again to close it after sufficient amount of light has passed through to impress the image upon the sensitive plate.

Cap. The simplest of shutters is the cap, which is a shallow box fitting closely over the front of the lens barrel. For exposures of several seconds or more in duration, the cap offers the most convenient means, while for exposures of less than one-half second, the cap can hardly be removed and replaced quickly enough, and some sort of automatic opening and closing device should be used.

Leaf. The leaf shutter consists of hinged leaves which meet and overlap to close the lens opening. They are forced open by a spring and forced closed by a spring. An exposure of as brief a space as $\frac{1}{100}$ second is feasible with the leaf shutter; and some shutters are advertised to make even shorter exposures. By the addition of an air piston, the closing of the shutter may be delayed until after the piston has completed a predetermined travel, thus giving an exposure longer than the shortest of which the shutter is capable. The usual "automatic" leaf shutter may be "set" before exposure to give an exposure of from one second to $\frac{1}{100}$ second. The shutter may be adjusted also to hold the lens open until released. Exposures longer than one second may be made by the "time" adjustment, opening the shutter at the beginning of exposure and closing it after the proper lapse of time, as in the case of exposure with the cap. The leaf shutters usually work between the lenses, near the diaphragm.

Curtain. The curtain shutter consists of two curtains on spring rollers inside the camera just behind the lens. When the shutter is adjusted for exposure, one of the curtains is in front of the lens; the other is above, rolled up. Upon release of the shutter, the lower curtain rolls down, opening the lens; after the desired lapse of time, the upper curtain unrolls and passes down, stopping over the lens and closing it.

Focal Plane. The focal plane of the camera is the position of the image formed by the lens. When ready for an exposure, the sensitive plate is located in the focal plane. The focal-plane shutter, which is a curtain just in front of the plate, is so called because it is placed as near to the plate as possible and, therefore, near the focal plane of the camera. The curtain has a slit which may be adjusted in width or it has several slits of different widths. When released the curtain rolls without stopping, and the length of time during which the light is permitted to shine upon the plate is determined by the speed of the curtain and by the width of the slot. With a shutter of this type, exposures as short as $\frac{1}{1000}$ second may be given. The shutter is available equally for longer automatic exposures and for time exposures.

Testing. An automatic shutter has a scale for setting the speed of the shutter, usually marked 1, 2, 5, 25, 100, meaning, respectively, 1 second, $\frac{1}{2}$ second, $\frac{1}{5}$ second, $\frac{1}{25}$ second, and $\frac{1}{100}$ second. The exposure given to the plate is not always true, however, to the value indicated by the scale of the shutter. The method of test is:

Photograph with the automatic shutter at one of its settings an object moving at a known speed; then calculate the length of time of the exposure from a measurement of the amount of movement visible in the photograph. The distance moved in the photograph is to the distance moved by the object during the exposure as the focal length of the lens is to the distance of the lens from the object. When the distance moved by the object and the speed of the object is known, the time required to move through that distance may be known, and that is the actual exposure of the shutter for the speed setting under which the test was made.

A wheel driven at a constant and known speed may carry a mirror on its face near its edge, the mirror reflecting the light of the sun or of an arc lamp into the lens. In this case, the distance and focal length need not be measured; the angle of the arc which the revolving mirror makes upon the plate while the shutter is open will give the duration of the exposure for the shutter setting under which the test was made.

Under test, a new fabulously high-priced leaf shutter showed an accuracy of only 60 per cent. Another cheap leaf shutter gave exactly the same length of exposure for its $\frac{1}{25}$ marking and for its

$\frac{1}{100}$ marking, the exposure being $\frac{1}{35}$ second for either of them. A fair shutter test easily made is as follows:

With stop f/11 and shutter speed $\frac{1}{25}$ expose a plate, and with stop f/64 and cap, time, or bulb exposure, give 1 and $1\frac{1}{4}$ seconds as accurately as possible. These exposures are nearly equal, and when developed in the same tray or tank the plates should be alike.

The speed markings of a new shutter may be accepted as correct; the medium speeds $\frac{1}{5}$ and $\frac{1}{25}$, which are used most by the amateur, are likely to be nearly accurate. The shorter exposures are likely to be too long; the longer ones are likely to be too short. An old or second-hand shutter should be tested for speed before good work is attempted with it.

Plate-Holder. For experimental work for the purpose of gaining a knowledge of photography sufficient for the making of motion pictures or good still pictures, glass dry plates should be used. Cut films or roll films may be adopted later, but the more reliable glass dry plate should be used by the beginner.

The plate-holder has two draw slides, and when each is drawn there is revealed a set of clamps for holding a glass plate inside the holder. The handle, or edge, of each slide is white on one side and black on the other. In the dark room, by dim ruby light, place a glass plate in each side, with the film, or dull, side facing out, and replace the slides, white side out. The plate-holders should be numbered on each side, the first holder being *1* on one side and *2* on the other; the second holder being *3* on one side and *4* on the other, etc. When exposing plates, always expose first the No. *1* side of the first holder, or the No. *1* plate, then the No. *2* plate, then No. *3*, etc. Upon returning to the dark room for development, the subjects upon each plate will be remembered by remembering the order of the exposures, and it is likely that only one exposure will have been made upon each plate. Without some system for exposing plates in order, it is possible that upon development one plate will show a ship sailing through a forest, and another plate will show nothing but the fog of an imperfect ruby lamp.

The camera is so arranged that the ground glass may be removed and the plate in its holder substituted. The removal of the ground glass may be by actually taking away the frame which holds it, but the more common method in small cameras is to force the plate-

SCENE FROM "THE TREASURE OF THE FOREST," BY GAUMONT
This is a Hand-Colored Film, the Plot of Which is Laid in the Days of the French Revolution.
Courtesy of the *Kleine Optical Co.*, *Chicago*

holder into the camera in front of the ground-glass frame, the ground-glass frame being held by springs which yield to permit the plate-holder to enter. When the plate-holder is removed subsequently, the ground-glass frame automatically resumes its proper position for focusing.

Darkroom. The darkroom is a room which is not merely dusky, but a room which has absolutely no white light. It may have red light until it is far from dark, hence "darkroom" is but a name. It must not have any light which will affect the sensitive plate. No daylight. Windows, doors, and transoms must be examined for cracks. After remaining in a darkroom for a few minutes, cracks will be seen which were not noticed at first. A bathroom at night makes a desirable darkroom for photographic operations. A movable platform across the tub offers a work table, and running water is convenient. A ruby lamp must be purchased. If a satisfactory screen is made for the window, such a dark room may be used during the day. No white light must get to the plate except through the lens during the interval of exposure. A little practice enables the photographer to load his plate-holders by touch alone, no light being needed. This enables plate-holders to be loaded in daytime in any closet by a little care in closing the cracks around the door.

A convenient darkroom may be built of rough boards in any corner of any room, basement, attic, or barn, the cracks being carefully closed by papering inside and outside. A developing shelf should be the height of the waist. If running water is desired in the darkroom, a sink should be convenient to the developing shelf, but running water in any but a very large darkroom is an objection rather than an advantage. In the wall back of the developing shelf a window should be cut into which a sash is fitted carrying a ruby glass. Outside of the darkroom, on a shelf or bracket, should be the lamp for furnishing the ruby light, so placed as to shine through the window. Shelves for chemicals, apparatus, and supplies are outside the darkroom. The darkroom contains nothing but a developing shelf, a door, and a window provided with removable colored glass. Dishwashing, and other processes not necessarily darkroom processes, may be done elsewhere.

Routine of Camera Operation. Select the view. Open lens. Open stop. Focus and manipulate the camera until you have upon the ground glass the image you want, no more, no less. Decide upon the stop opening to be used and the length of exposure to be given. Set stop opening. Close lens. Adjust shutter to selected speed setting. Insert plate-holder. Draw dark slide of plate-holder. Release automatic shutter or otherwise make the exposure. Replace dark slide in plate-holder, black out. Remove plate-holder from camera.

Practice this routine without plates in the holders, or without drawing the dark slide from the plate-holder, until entirely familiar with all of the steps. Many plates are spoiled by drawing the dark slide before closing the lens, or by failure to draw the dark slide at all.

PRODUCING THE IMAGE

The picture is made upon the ground glass of the camera. If the photographer has the patience and skill, or the good luck as an amateur, to secure such an arrangement of his subject upon the ground glass as makes a good picture there, then the mechanical and chemical processes which follow will merely record that picture and will produce a pleasing photograph unless the record should be spoiled by accident. The view selected to be photographed often is forced upon the photographer. He must produce a picture of this house, or that bridge, or of the children of the family. The motion-picture camera man must photograph the set stage or such other subject as the producer in charge may direct. Yet the control of the image in nearly every instance is so completely in the hands of the camera operator that the resulting picture is better or worse as he is careful or careless, and according as he understands the possibilities of his camera to control the arrangement of the details of his subject. All of this control of the resulting picture, after the voluntary or enforced selection of the principal subject, must be exercised before the exposure of the sensitive plate or film is made by the operation of the lens shutter. After the lens has been opened upon the subject, transmitting the light of the image to the sensitive plate, no further change can be made in the picture.

The making of the picture, that is, the making upon the ground glass the image which is to be recorded to become the finished photograph, may be divided into seven points for consideration and study, as follows:

(1) The selection of the principal object to be photographed.

(2) The selection of a background or setting for the principal object.

(3) The lighting or direction of light falling upon the subject as a whole.

(4) The size of the principal object in the image.

(5) The composition and balancing of principal and subordinate objects in the image.

(6) The prominence of the background.

(7) The avoidance of disagreeable distortions in the image.

Principal Object. The total task of photographing usually is the making of a photograph which may be used to record some one object, such as a house, a tree, a flower, a person, or an animal. Sometimes it is merely "a pretty scene," but in this case the photographer should decide upon some object of the scene to form the principal object of the picture. He should give such prominence to some object that the resulting photograph will be in substance a picture of that principal object, yet will embody in its background or scenic setting the "pretty scene" which it was desired to photograph. Right at the beginning, and in the most fundamental of all of the principles of picture making, the camera operator has the power to control the image, to make or spoil the picture, even though commanded by an outside influence as to his general subject. Whether he is inspired by the beauty of a scene to make a photograph of it, or whether he is commanded by a companion or by an employer to make a photograph of it, he still has the power to make some object a principal object, to hold other objects subordinate to it, and to mold the whole into an arrangement in the image on his ground glass which will result in a photograph worthy the name of a picture when finished. Each picture must have a principal object or it is at best only a photographic memorandum.

Background. In portrait work in a studio, the backgrounds are painted as desired, and brought in or carried out, and turned and placed as needed. And for scenic work it is almost the same. Suppose that it is commanded that a photograph be made of a rose-bush in blossom in the front yard of a house. If the house would form a desirable background, set up the camera at the front fence. If the front fence would form a desirable background, photograph the rosebush from the house. If either side fence is better, place the camera at the opposite side of the yard. If none of the surroundings are pleasing as background objects, there is still the possibility of viewing the bush from above so that the grass of the lawn, and not any fence, house, or other object is included as a background. This view may be had from the top of a stepladder, from an upper window of the house, or even from the height of the tripod above a porch floor. With some of these background arrangements surely the resulting picture will be better than with others. Get the best one, just to show that you are master of the camera, even though some one else dictates what your principal object shall be.

When photographing persons or animals, the "principal object" usually may be brought to a suitable background. When photographing a house, the inclusion in the image upon the ground glass of a little more of the foreground, or of a little of one of the houses standing at one side of the "principal object," or of a tree standing near, partakes of the fundamental principle of the selection of a background and gives the camera operator some power to make his image nearer to a picture and farther from the memorandum type of photograph.

Lighting. With immovable objects, such as trees, houses, and rosebushes, illuminated by the sun, the photographer has two methods of controlling his lighting, both of which consist merely in taking advantage of natural conditions by the selection of the proper time for making the exposure. The sunlight falls upon the object at different angles and in different directions at different hours of the day. Whether the object is photographed in the early morning, in the late morning, at noon, or in the afternoon is usually within the control of the photographer, and it makes a difference in the pictorial value of the photograph. Few landscapes are pretty at noon, with the shadow exactly under each tree and bush; they are far better between two o'clock and five o'clock in the afternoon. The horizontal rays of sunlight become objectionable again in the late afternoon. The second method of control for immovable objects is the selection of an overcast or hazy day in preference to a day of direct sunlight. Usually the direct sunlight, with sharp shadows is preferable, but here again the operator has control of the image in his hands.

Size of Object. The size of the principal object is controlled by the distance from the camera to the object and by the focal length of the lens. The nearer the camera is carried to the object to be photographed, the larger will be the image of that object upon the ground glass. The longer the focal length of the lens used, the larger will be the image upon the ground glass. The image of the main object, therefore, may be enlarged by using one of the lenses alone instead of both of them double.

Composition and Balance. By the terms composition and balance reference is made to the many relations which exist among the masses of light and shade among the lines of the image. The rules are so numerous that all of them cannot be followed at all times, and many of them apply only to specific instances of subject arrangement. A few of the more general rules may be kept in mind when arranging the image upon the ground glass.

A profile portrait shows on one side the light face against the darker portion of the background, and on the other side the dark hair against the lighter portion of the background. Each side of the picture has its lights and its shadows. A landscape, even the picture of a building, should bear the same analysis. A balanced picture should have a principal shadow, and some minor shadows. It should have a principal high light and some minor high lights. With the principal shadow and the minor high lights on one side of the image and the principal high light and minor shadows on the other side, it is likely that an approximate balance will be obtained. For example: a heavy mass of foliage is at the lower right, as a near bush or tree; a few scattered masses are at the middle left and upper left, as distant bushes or trees; a roadway or stream runs from lower left to upper right, showing a large light spot at lower left and smaller light spots at upper right; the large light is a little higher or a little lower than the large shadow, not dead level that a line connecting them would be parallel to the margin. That sounds like a coldly critical analysis suitable for producing a stiff and formal picture, yet a scene sought out in nature and photographed from a viewpoint carefully selected to secure this arrangement of lights and shadows will rank above a hand-camera snapshot and will repay the amateur's effort.

In a water scene, a ship at anchor may be photographed from the pier with another pier in the background. Place the dark hull of the ship near the lower edge of the picture and at the right of the middle line; place the distant pier above the center on the left of the picture. The masts of the ship cut up into the upper right corner and break up the sea and sky into minor high lights. The major high light is the unbroken sea at the left of the ship, lower left corner of the picture.

Strictly parallel lines are objectionable in a picture unless they are parts of an object and unavoidable, as the masts of a ship. Any line parallel to the margin of the plate is objectionable except the side lines of buildings, which are unavoidable. An imaginary line joining two high lights or two shadows should not be parallel to an edge of the plate, nor should an imaginary line from the principal shadow mass to the principal high light be parallel to any edge of the plate if it can be avoided. The horizon line requires care in this detail.

Horizon Line. The placing of the horizon line has much influence in the composition and balance of the picture. Care must be taken that the horizon line does not cross the principal object at an undesirable point, nor should the apparent horizon divide the picture exactly in the middle. Where a hillside is included in the landscape, it may be made to give an inclined or irregular line for the horizon. Where a level horizon is unavoidable, it should be broken if possible by the objects of the picture.

Point of View. The point of view is the location of the camera whence the image is made. Changing the point of view is the most powerful means which the camera operator has for arranging and controlling his image. The selection of the background depends almost solely upon the point of view chosen. The size of the principal object is largely controlled by the choice of the point of view, while the composition and balance are almost wholly controlled by the selection of the point of view, together with the selection of the lens length.

Prominence of Background. As a rule, the image may be separated into principal object and background, even though the background or setting of the principal object be really the more important portion of the picture, and the portion primarily desired. The relative size of the principal object and its associated background objects may be controlled by the lens length. With the double lens, focus upon a view containing a near tree as a principal object. Note the size of the distant trees. Remove the front lens cell, move the camera back to twice the distance from the principal tree, and focus again. By the change of the lens and the change of the point of view, the principal tree will be the same size as before; note that the distant trees are much larger than before, thus giving greater prominence to the objects of the background. Also, by the use of the longer focus of the single lens, less of the horizon is included in the image, and less of the surrounding landscape is shown as a background to the principal tree, that which is included in the image being shown in larger size. If the front and back cells of the lens

Fig. 23. Perspective Distortion

are different in length, the front cell alone will give still more prominence to the background objects, a greater extension of bellows and a still more distant viewpoint being required to keep the principal object at the original chosen size. When it is impossible to secure a point of view near enough to the principal object to secure a large image, the longest lens will give the largest possible image.

In the case of a portrait, the background is entirely unimportant in detail, and is most satisfactory when shown merely as a blurred surface of light and shade. This is effected by opening the diaphragm to its largest stop size, then bringing the face of the portrait to a sharp ocus. The background will be blurred because it is "out of focus." Out-of-door portraiture profits by the same rule, and the rule applies generally where the picture is to be a photograph of a specific object and the background is not a part of the object. Where both foreground and background are required to be sharp, a small stop opening must be used to secure the result.

Distortions. Usually, any distortion of the image caused by the lens is objectionable. Blurring the background in portraiture and similar pictures by using the shallow field incidental to the large stop opening is in itself a form of distortion which is made to serve a useful purpose and is an aid to the operator in the control of his image.

Barrel distortion and pin-cushion distortion, which have already been discussed, should be avoided as far as possible, particularly in architectural subjects.

Perspective distortion will be observed if the camera does not stand level upon its tripod. In landscape views, such distortion

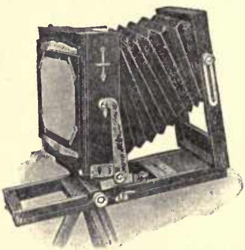


Fig. 24. Camera with Swing Back in Use

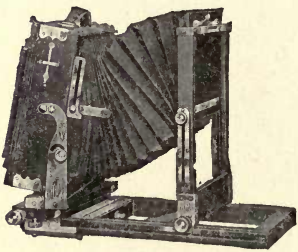


Fig. 25. Camera with Rising Front in Use

usually is negligible. In architecture it is ludicrous, Fig. 23. The remedy is to keep the ground glass vertical, or nearly so. This is done by the swing back and by the rising front.

Swing Back. When the back of the camera, carrying the ground glass and the plate-holder, is pivoted or hinged, the body of the camera may be tilted to bring the desired scene upon the ground glass, and the swinging back of the camera then may be adjusted to bring the ground glass vertical or nearly so, Fig. 24. By this adjustment, the perspective distortion will be corrected, but the focus is more difficult and a smaller stop opening will be required to give a sharp focus over the entire plate.

Rising Front. With the camera placed about level, more of the sky or more of the foreground may be included upon the plate by raising or lowering the lens in the front of the camera, Fig. 25. This avoids perspective distortion, but the amount of adjustment thus obtainable is somewhat limited.

RECORDING THE IMAGE

The recording of the image consists of two processes—exposing the sensitive plate and developing the exposed plate into a negative.

Dry Plates. The art of the chemist is brought into use in recording the image of the lens. The known substance most sensitive to light is finely divided nitrate of silver suspended in gelatine. The manufacture of this substance is not attempted by the photographer. A thin skin of the prepared gelatine is spread upon glass plates and dried. The plates thus made are sold under the name of photographic dry plates. These are bought by the photographer in light-proof sealed packages and loaded into plate-holders in the darkroom.

Films. Flexible transparent celluloid films coated with the prepared gelatine are used instead of the glass, if desired, and may be had for pictures up to a 5 by 7 size, either in packets of cut films or in rolls of proper width on which exposures may be made one after another. In motion-picture work, the celluloid film is a necessity and it is used universally in commercial motography.

Exposure. When the plate-holder is inserted in the camera, the lens closed, and the dark slide withdrawn, the lens is opened just long enough to permit a sufficient amount of light to pass through the lens to affect the sensitive silver of the dry plate—neither too much, nor too little. This process of administering to the plate the proper dose of light in the form of the image is called *exposing the plate*.

The greatest problem in photographing any subject is the best arrangement of the image upon the ground glass, and the next greatest is the determination of how long a time, in seconds or fractions of a second, to permit the light to flow through the lens to impress the image properly upon the sensitive plate.

The amount of light from a given subject which falls upon the sensitive plate to impress the image depends upon the size of the stop opening and the length of time during which the lens is left open for the exposure. Light flowing through the stop opening is just like water flowing through a hole. If you increase the size of the hole, the bucket will be filled with water in less time, and in direct proportion to the change of the size of the hole. *Double-size hole, half the time to fill the bucket. Half-size hole, double time to fill the bucket. A hole ten times the size will fill the bucket in one-tenth the time.* This rule holds strictly true in the case of the photographic exposure. Increase the size of the stop opening and the light passes through faster, giving the plate sufficient light in a shorter time.

A larger plate requires a greater quantity of light because there is more surface to be worked upon. The light spreads from the lens, and the farther back from the lens the light must go to reach the plate, the more it spreads out and the weaker it becomes. *The lens length has a direct influence in the strength of light upon a plate from a given subject through a given opening* or, to state the same rule differently, *the lens length has a direct influence in determining the size of stop opening which must be used to effect the same strength of light upon a plate from a given subject.*

Stop Numbers. A plan of numbering stops according to the size of the opening has been devised which removes the actual focal length of the lens from the calculation of the strength of the light upon the plate, by including the focal length of the lens in the determination of the stop number. There are in common use in America two systems of stop numbers—the *focal-factor* system and a modification called the *uniform system.* The plan used in the focal factor system consists of numbering the stops in fractions, as 1/8, 1/16, 1/32 of the focal length of the lens; these are written *f*/8, *f*/16, *f*/32, etc., or *F*/8, *F*/16, *F*/32, etc., or *f*-8, *f*-16, *f*-32, etc., or *f*:8, *f*:16, *f*:32, etc.

The stop number *f*/16 means that the diameter of the stop opening is 1/16 the focal length of the lens. An *f*/16 stop for a 4-inch lens is 1/4 inch in diameter. An *f*/16 stop for an 8-inch lens is 1/2 inch in diameter, giving four times the area of the stop opening, giving four times the quantity of light, but since the light goes twice as far before it reaches the ground glass or sensitive plate it will spread over four times the area and, therefore, will be of the same strength, or intensity, on the plate with the 1/2-inch stop *f*/16 of the 8-inch lens as with the 1/4-inch stop *f*/16 of the 4-inch lens. This is of great convenience in writing of exposure timing, because by the use of the focal-factor system of stops all the rules given for exposure will be true for cameras of all sizes and for lenses of all lengths of focus.

In both systems each stop number requires either double or half the exposure of the next stop number, the stops being alike at *f*/16 and No. 16. If the stop numbers on a scale are 4, 8, 16, 32, 64, 128, 256, it is "U. S." or uniform system. If the stop numbers on a scale are 8, 11, 16, 22, 32, 45, 64, it is focal-factor system. In either case, as the numbers increase each number requires double the time of exposure required for the preceding or next smaller number. In any lens, the largest opening possible may not be an even stop number, and this first marking of the scale may vary from the "double time" rule. Thus, if a lens will work with an opening of *f*/7, its scale will be marked 7, 8, 11, 16, etc., if for the focal-factor system; or 3, 4, 8, 16, etc., if for the "U. S." system. In Table I the numbers in the two systems are compared.

TABLE I

Equivalent Stop Numbers in Focal-Factor and Uniform Systems

f/2	f/3.5	f/4	f/4.5	f/5	f/5.6	f/6.3	f/7
No. ¼	No. ¾	No. 1	No. 1¼	No. 1½	No. 2	No. 2½	No. 3
*f/8	*f/11	*f/16	*f/22	*f/32	*f/45	f/64	f/90
No. 4	No. 8	No. 16	No. 32	No. 64	No. 128	No. 256	No. 512

*The stop numbers in the two systems which are most commonly met and used.

Plate Speed. Some plates are coated with a gelatine film which is more sensitive to light than others. As a standard, plates such as Seeds 26x, Stanley, Hammer Fast, Cramer Instantaneous Iso, and Standard Extra may be taken as most suitable in speed for amateur work. These plates list 130 on the Watkins scale of plate speeds. A faster class of plates comprises Cramer Crown, Hammer Extra Fast, Seed 27, and Kodak and Premo Films. These list at 180 on the Watkins scale and require only three-quarters the exposure to impress the image as fully as upon a plate of the 130 class.

Light Intensity. In filling a bucket with water running through an opening, the pressure which is behind the water will influence the rate of flow and will influence the time required to fill the bucket. The intensity of the light which illuminates the subject and the nature of the subject itself are the two elements which influence the rate of flow of light through the lens opening. On a dark day the light does not pour through the small stop opening as fast as on a day of blinding sunlight. Even in the same bright sunlight, the quantity of light sent to the camera from a dark green tree is less than the quantity sent from the white sails of a ship. One consideration of the nature of the subject also is its distance from the camera.

If the average amateur photographer were asked the exposure for a summer landscape, he would probably say, carelessly, *f*/16 and 1/25 of a second. That is the hand-camera way and gives but twenty good negatives out of a thousand exposures.

The intensity of light depends upon the height of the sun above the horizon, which varies with every day of the year and with every hour of the day. With a clear sky and an average subject, Table II gives in seconds the proper exposure (Watkins 130 list plate) for *f*/16 stop for each hour of the year, by months, for the latitude of the northern portion of the United States.

In the southern portion of the United States, three-quarters of this exposure is sufficient; and on the equator, probably one-half is sufficient, and the May-June-July column may be used all the year around, with the 5 A. M. and 7 P. M. figures omitted.

For a hazy day—good daylight but cloudy enough to obscure the sun—give double the exposure as a correction for the clouds. On a heavily overcast, gloomy day, give four times the exposure as a correction for clouds.

Nature of Subject. The nature of the subject to be photographed has an influence even greater than the time of day or condition of the clouds. For pictures in the middle of the day, a glance at the table shows that the midwinter exposure with sun is but little more than double the midsummer exposure with sun. The exposure for cloudy days is only twice or four times that for sunny days. But the correction for the nature of the subject even with outdoor subjects may be two hundred times as much for one subject as for another.

The following corrections may be applied to Table II to com-

TABLE II

Day and Hour Exposure Chart

A. M. P. M.	Jan.	Feb.	Mar.	Apr.	May June July	Aug.	Sep.	Oct.	Nov.	Dec.
5 A.M.					1					
6 A.M.			1	1/2	1/5	1/2	1			
7 A.M.	2	1/2	1/5	1/10	1/10	1/10	1/5	1/2	2	2
8 A.M.	1/2	1/5	1/10	1/10	1/10	1/10	1/10	1/5	1/2	1/2
9 A.M.	1/5	1/10	1/10	1/15	1/15	1/15	1/10	1/10	1/5	1/5
10 A.M. to 2 P.M.	1/10	1/15	1/15	1/25	1/25	1/25	1/15	1/15	1/10	1/10
3 P.M.	1/5	1/10	1/10	1/15	1/25	1/25	1/15	1/10	1/5	1/5
4 P.M.	1/2	1/5	1/10	1/10	1/15	1/15	1/10	1/5	1/2	1/2
5 P.M.	2	1/2	1/5	1/10	1/10	1/10	1/5	1/2	2	2
6 P.M.			1	1/2	1/5	1/2	1			
7 P.M.					1					

pensate for the difference in the character of the subject of different images.

1/20 exposure for sky and clouds, where the foreground objects do not form a part of the picture.

1/10 exposure for sea and sky, ships at a distance at sea, views at a distance across the water.

1/4 exposure for open views, where the important portion of the view is in the distance and the foreground is unimportant.

1/2 exposure for very light objects of importance in the foreground.

Exposure time given in the table is suitable when the important objects of the image are 20 to 100 feet from the camera and are neither white nor black, neither very light nor very dark.

Twice the exposure time given in the table for objects nearer than 20 feet, or for dark objects of importance in the foreground of the image.

Four times the exposure time for portraits in shade of heavy foliage, and for dark objects nearer than 20 feet.

Sixteen times the exposure time for pictures in dense woods where side light as well as top light is obstructed by the foliage of the trees.

Near sunset, five times the exposure in order to compensate for the yellow color of the sunset light.

Interiors, if very well lighted by windows and with light walls, 100 times the table values.

Interiors, if not well lighted, 500 to 5,000 times.

When the sun is in front of the camera so that the shady side of the subject is being photographed, the exposure should be doubled.

Calculation of Exposure by Table. To calculate an exposure requires that the proper *f*/16 time for average plate and subject be taken from Table II. If the subject is an average one and the summer day is bright, then there is no correction to be applied, the stop is set to *f*/16, and the figure taken from the table is set upon the automatic shutter and the exposure is made. A few exceptions may be studied.

The summer hotel presents from across the valley a view which the visitor wishes to take with him. At one point in the road a group of trees between the road and the hotel obscures the hotel, but by taking a viewpoint farther along the hotel is free from the obstruction and the group of trees at one side of the middle of the image balances the hotel at the other side. The trees being nearer and larger are the "main object" of the composition, but the building is the more important. It is painted white. Trees behind it show its outline definitely, and both the trees behind and the "main object" group of nearer trees break the horizon line. The horizon line is placed high—three-fifths from the bottom and two-fifths from the top line of the picture. If possible, the camera is so positioned by its selection of viewpoint that some small object breaks the foreground on the side opposite the "main object" group of trees. The exposure is: Summer, 2 P. M., by Table II, 1/25 second; important portion of the view is in the distance and foreground unimportant, correction 1/4; the exposure should be 1/100 second at *f*/16, but better 1/25 second at *f*/32 to increase the sharpness of the distant object. *In a light subject, give less rather than more time than given in the table.*

Fig. 26. Watkins Exposure Meter

Further along, the visitor passes through a wood and notes a clump of pretty ferns. The table says 1/25 second; correction for deep wood, 16; correction for dark color (green) of ferns, and near the camera, to have the image of the ferns large, 4. Time 64/25 or

$2\frac{1}{2}$ seconds at $f/16$. *In a dark subject, give too much rather than* too little time by the table.

Exposure Meters. The exposure meter is a device for measuring the strength of the light which falls upon the subject. It takes the place of Table II and of the correction for the clouds. Two types of exposure meters in general use are the Watkins, Fig. 26, and the Wynne, Fig. 27.

The principle of both meters is the same. A disk of paper which is discolored rapidly by light is movable behind a slot, and beside the slot are bits of color which the paper matches in the course of its discoloration under the influence of light. The more intense the light, the more rapidly does the exposed bit of the paper disk become discolored, and the sooner does it reach a tint which matches one of the bits of color adjacent to the slot. The time required to match the darker color is taken as actinic value of the light. An exposure-calculating disk forms a part of each meter. Upon and near the calculating disk are sets of figures for (*a*) the actinic or meter value of the light, as noted in the number of seconds which is taken by the paper to discolor to match the dark standard tint; (*b*) the speed of the plate which is to be used in the exposure; (*c*) the diaphragm stop; and (*d*) the required exposure in seconds or fraction of a second.

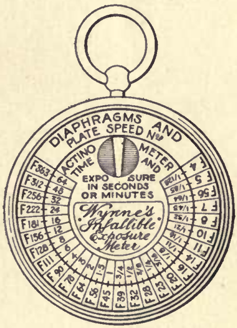


Fig. 27. Wynne Exposure Meter

The difference between the two meters is found in the calculating device. In the Watkins, the stop number is set opposite the plate number; then opposite the time required for the paper to darken is found the time required to impress the image upon the plate, that is, the exposure time, to which the correction for the nature of the subject must be applied. This appears to be the more convenient meter for the amateur either with hand camera or tripod. In the Wynne, the time required by the paper to darken is set opposite the speed number of the plate; then opposite the stop number is read the required exposure for a standard subject, to which the correction for the nature of the subject must be applied. This is the more convenient for the motion-picture camera operator because of an exposure limitation in the motion-picture art. The Wynne meter is preferred by many fixed camera operators who have become familiar with it. Full instructions for use accompany either meter when purchased.

There are also upon the market many exposure meters, so-called, which are but calculating devices for combining the date table with the cloud correction, subject correction, stop number, and plate speed. Perhaps, when facility has been acquired with one of them, it would be found convenient.

Exposures with Single Lens. When the front lens of a double lens is removed, for the purpose of obtaining a larger image, or to increase the prominence of the background, the focal length of the lens has been changed, without changing the markings of the diaphragm scale; these markings, therefore, are not correct for the single lens. To obviate this, some lenses have two or three sets of markings on the diaphragm scale, one for the double lens and one for a single lens if both singles be of the same focal length, while if the singles be of different focal lengths there may be three markings, one for the double lens and one for each of the singles.

Where the singles are of the same focal length, the exposure time for a single lens will be four times that for the double lens with the same stop setting, to compensate for the difference in focal length between double and single.

Where the singles are of different focal lengths, the exposure for the short single will be three times that for the double lens, and the exposure for the longer single will be six times that for the double lens.

Duplicate Exposures. When much is in doubt, and upon subjects which cannot be photographed again, two exposures may be made, using two plates, and giving different lengths of exposure. If the range of exposure is such that one plate has ten times the exposure of the other both may give good negatives, whereas, if this ratio is increased to twenty-to-one, disappointment may be met by finding one plate under-exposed and the other over-exposed. As an over-exposure is a better printing proposition than an under exposure, a good rule for duplicate exposures is as follows:

SCENE FROM PHOTOPLAY, "IN OLD CALIFORNIA WHEN THE GRINGOES CAME"
Courtesy of *Selig Polyscope Co., Inc., Chicago*

PAYING HOMAGE TO THE QUEEN AT THE COURT RECEPTION
Scene from Photoplay, "The Son of the Executioner"
Courtesy of *Great Northern Film Company, New York*

Estimate the exposure, then give one plate half the estimate and the other plate five times the estimate.

Development. The subject having been selected and arraned upon the ground glass, and the sensitive plate having been inserted and exposed by setting the diaphragm as determined by judgment of the image, and setting and releasing the shutter as determined by meter or Table II and judgment of the nature of the subject, the field work for that particular plate is finished. Other plates may be exposed before developing the first, and development may be done either immediately after exposure or after a lapse of a few days or weeks.

The exposed plate is still sensitive to light and must be kept in the holder with the slide closed until removed in the darkroom. As the plate itself bears no evidence whatever of having been exposed, it is impossible to tell an exposed plate from an unexposed one except by applying a developer, which brings out the image if exposed and spoils the plate if unexposed. The indication in the field or in the darkroom that a plate has been exposed is the slide of the holder, which should have its white side out for an unexposed plate and its black side out for an exposed plate. The plate when exposed is said to contain a latent image, because the invisible image may be brought out and made visible by a process called *development.* This is done by soaking the plate in a chemical solution which turns the nitrate of silver black only where it has been struck by the light but does not affect it otherwise.

Negative Image. The gelatine film of the plate when developed shows the image which was seen upon the ground glass, but with its lights and shadows reversed. A black sky is seen above a white grassy foreground; a black brook flows under white trees; the figures in the picture are black of face and have white hair.

Developers. There are many different developers on the market, each with its claims. The selection is a matter of personal opinion, and in the writer's opinion there is no developer as good as pyro and soda, although it stains the fingers if the operator is careless about slopping around in the darkroom. Hydroquinone and metol developer is second choice, and this does not stain the fingers.

For the first few plates to be developed, the amateur should buy a ready-mixed developer, either liquid or powder form, to avoid the possibility of losing all of the first batch of plates through a error in compounding the developing solutions, and to avoid plac ing a blame upon improper exposure when the actual fault is an error in compounding the developer. Formulas for developers will be given after the processes of development with ready-mixed developers have been studied.

Trays and Covers. The developing tray is a flat dish having a flat bottom so the glass plate will lie close upon the bottom of the tray. Half a dozen should be available, each the proper size for one plates. Covers for the trays should be light tight. A good cover is a developing tray of such size that, when turned over the smaller developing tray, it will come down to the developing table or shelf all around the edge. Almost as good but not so convenient a cover is a folded paper larger than a tray laid across the top of the tray and a flat weight, such as a small piece of wood larger than the developing tray,which is laid upon the paper and holds it close to the top of the tray all around the edge. A measuring glass and a thermometer will be needed.

Ruby Lamp. A "safe" light is one which may shine upon a sensitive plate without spoiling the plate. Such a light is a theoretical proposition. | To determine whether your ruby lamp is safe, cover half a plate and expose for five minutes to the direct rays of the lamp two feet away. Then develop. If the half exposed to the light is fogged, the lamp is not entirely safe, although it may be good enough. Very few lights are safe which are strong enough to be of any use. It is quite possible to use an unsafe lamp without spoiling plates; that is the object of the tray covers. The writer has developed many plates and films when he did not have a red lamp at all.

Sight Development. In preparation for development, set a tray 18 inches or 2 feet from the red lamp. Beside it place the measuring glass or a drinking glass containing four ounces—for 4 by 5—or six ounces—for 5 by 7—of developer at 65 degrees by the thermometer, ready to pour upon the plate to be developed. Have a cover for the developing tray handy. A foot or more away, beyond the reach of splashes, place the plate-holder containing the exposed plate to be developed. A pan of water, larger than the plate, is convenient for rinsing the plate, and *outside of the darkroom* but near it is a developing tray containing half an inch in depth of a fixing solution made of four ounces of hyposulphite of soda dissolved in a pint of water. All of this in full white light, that no mistakes may occur. A clock or watch in the darkroom should be so placed that it may be read by the red light. Close the darkroom door and shut off all light but the red. When the eyes have become accustomed to the weak red light, open the plate-holder, lift the exposed plate by the edges, place it in the developing tray *film side up*, glance at the clock, pour on all of the developer, making half an inch deep over the plate and wait. If the plate is a landscape, soon one part of it will begin to look gray; this is the sky coming up under the action of the developer. This should be seen in from half a minute to one minute after the developer is poured on. Soon the outlines of objects in the foreground will be seen, and by the end of two minutes the picture will be completely visible. This is not half enough development. The picture will begin to fade away, to sink into the film, and the whole plate will get dark on the surface. When the picture has had five or six minutes and seems completely spoiled, lift the plate by the edges and see whether the heavier and darker spots have come through upon the back of the plate. If the picture is visible upon the back, through the glass of the plate, it is likely that the negative is very good. Rinse in the pan of clean water for fifteen seconds or more, that the developer may be washed out of the film as well as washed off the surface, then open the darkroom door and place the developed plate in the tray of hypo outside; wash the hands free from hypo before going back into the darkroom. At this time, the negative will show the black image upon a milky film. When held to the light, the plate is opaque and the image blurred. After five minutes in the fixing bath the "milk" of the film should be fading rapidly, and ultimately there will be left only clear glass, easily seen through, with the image sharp and black. This is *sight development*. The plate is watched all the time, and when the image is strong enough, usually judged by its being visible through the back of the plate, the plate is taken from the developer, rinsed, and placed in the hypo fixing bath. For this method of development, strong, medium, and weak developers are used. Plates which seem slow in coming up are put in strong developer, while plates which come too fast are placed in weak developer. Few people understand sight development, and it requires an experienced eye to decide when the development should be stopped. It is not a good method for an amateur, but it should be used for the first plate, that the amateur may see what the process of development really is, even though the first plate be spoiled in learning.

Factorial Development. This system is a modification of the sight development system which brings development within the range of the amateur. The developer should be mixed according to a standard formula, it should be at 65 degrees by the thermometer, and the factor should be known. With ready-mixed developers, the factor usually is printed on the wrapper of the package.

A plate properly exposed will show gray in the sky in one-half minute and be fully developed in six minutes. A plate which has had a little too much exposure will be fully developed in five minutes, but it will show its first gray in twenty-five seconds from the time the developer is poured on. A much over-exposed plate will be fully developed perhaps in three minutes, but it will show its first gray in fifteen seconds. An under-exposed plate may need twelve minutes of development, because with the less exposure the image builds up more slowly and also appears at first more slowly, taking one minute to show its first gray. It has been noted that the total time of development required is always—with pyro developer—about twelve times the time required for the plate to show its first gray, hence, we have this factorial development system with this rule:

Have the developer at 65 degrees, and notice the time from pouring it upon the plate until the first gray is shown. Cover up the tray and wait until it has devoloped twelve times that long; then wash it and place it in the fixing bath. This method protects the plate from the red light except for the first minute, and even this may be reduced by holding the tray cover between the tray and the light and only removing the cover for a second every five or ten seconds until the first gray is noticed. This is a thoroughly practical system for amateurs. Two or more plates may be started at once in different trays, and still others started while these are developing. The time for taking out of the developer may be written on a slip of paper placed on top of each tray cover.

Tank Development. By the name, this is a large tank, capable of holding several plates, or several dozen plates, and filled with developer. The developer is at 65 degrees. The plates are put in, left twenty minutes, taken out, rinsed, and placed in the fixing bath. This is a simple method used by professionals and suitable for amateurs. It merely requires care that the developer is standard strength and standard temperature.

In the amateur's darkroom, this tank method operates as follows: Prepare developer according to tank formula; by red light place a plate in a tray and fill the tray with tank developer at 65 degrees; wait twenty minutes; remove plate, wash and fix in the hypo bath. In hot weather, the trays should be cooled to 65 degrees or they will heat the developer; in cold weather it may be necessary to warm them to 65 degrees. This method sometimes is called the *time and temperature* method. With a few plates to develop it is not economical of time nor of developer but the results will average higher in quality than with either sight or factorial method of development in the hands of an amateur.

Developing without the Red Lamp. To develop without the red lamp is merely a matter of *time and temperature,* and handling the plates by touch. By white light, pour the developer into the tray (65 degrees); have the cover at one side and the plate-holder at the other. Put out the light and in darkness remove the plate from the holder, place it in the tray of developer, and place the cover on the tray. Light the white light, look at the watch, wait twenty minutes, remove the plate in white light, rinse quickly and thoroughly and place in the fixing bath. The secret of this process is that white light followed quickly by a fixing bath does not injure the plate.

Washing before Fixing. The plates should be washed before fixing in order to keep the developer out of the fixing bath. The negatives will become stained in the fixing bath if this is not done.

Fixing. The milky silver of the plate must all be removed. To insure this, the plate should be allowed to remain in the fixing bath after the milky appearance is gone for a time half as long as was required to remove the milky appearance.

Fixing after Washing. The hyposulphite of soda must be thoroughly washed out of the film or the negative will spoil with age. An hour in running water, or soaking for fifteen minutes each in six changes of water should insure the complete removal of the hypo. The plate then is set on edge or placed in a rack to dry in a place where dust will not settle upon its sticky wet surface.

Developing Formulas. A convenient method for compounding developers is to open an ounce box of pyro or other developing agent and weigh it all out into quantities each of which will make one pint of developing solution ready for use. These quantities may be wrapped in waxed paper and packed in an air-tight can, bottle, or box. Similar powders of soda may be made up, and when developer is wanted it is necessary only to take one powder from each can and dissolve in a pint of water.

Pyro Developer:

First powder—14 grains pyro

Second powder—80 grains sulphite of soda, anhydrous
55 grains carbonate of soda, anhydrous

For sight or factorial development, take one each of the powders and 16 ounces of water. Temperature 65; factor 12. A normal exposure should develop for about six minutes.

For tank, or "time and temperature" development, take one each of the powders and 36 ounces of water. Temperature, 65; time 20 minutes.

Pyro developer can be used only once except for sight development, and even then it is not advised. It must be used within a few minutes after dissolving but will keep indefinitely before dissolving.

Hydro-Metol Developer:

First powder— 14 grains metol
14 grains hydroquinone

Second powder—104 grains sulphite of soda, anhydrous
104 grains carbonate of soda, anhydrous

Dissolve separately one each of the powders in 8 ounces of water; pour together, making 16 ounces of developer for sight or factorial development. Temperature 65; factor 15.

For tank, add water to make 36 ounces of developer; temperature 65; time 20 minutes.

Hydro-metol developer may be used repeatedly for sight development, but works more slowly after the first use.

Plain Hypo Fixing Bath:

4 ounces hypo crystals
16 ounces water

This bath will keep indefinitely until used, but will not keep after it has been used. It may be used for several plates but works more slowly after the first. Wash the plates well before putting them into the plain hypo bath, for a little developer in the plain hypo will stain the plates if they are left in the bath long.

Acid Hypo Fixing Bath:

16 ounces water
4 ounces hyposulphite of soda, crystals
80 grains sulphite of soda, anhydrous
60 grains powdered alum
1 dram citric acid

Dissolve completely the hyposulphite and the sulphite before adding the alum and citric acid, or the bath will be milky and less efficient.

The acid fixing bath will keep before and after using. It may be used repeatedly as long as it will dissolve the silver from the film, but it works more slowly after the first use. It is less likely to stain the negative from developer, but will do so if too much developer gets into it, and after it becomes weakened with repeated use. It should not be used after having become discolored with developer, for fear of stains upon the negative.

Removing Pyro Stains. Negatives stained with pyro may be cleared after washing and drying in the usual way by immersing in a bath of

3 ounces iron sulphate (copperas)
16 ounces water
¼ ounce sulphuric acid
1 ounce powdered alum

Wash and dry as after fixing. The pyro negative has an olive green natural color which adds much to its good printing qualities. This color is not a stain, and should not be removed. The copperas clearing bath will remove the yellow blotches which sometimes appear on pyro negatives because of developer in the fixing bath.

Intensifying a Negative:

First solution—120 grains mercuric chloride
120 grains potassium bromide
12 ounces water

Second solution—1 ounce sulphite of soda
8 ounces water

Soak the negative in the first solution until it is white, then wash thoroughly and soak in the second solution until it is as dark as desired. Wash thoroughly and dry.

Reducing a Dense Negative:

32 ounces water
1 ounce hypo
15 grains of red prussiate potash

Dissolve the hypo completely in half the water; dissolve the potash in the remaining water; and pour the potash into the hypo.

Reducing Contrast in Negative:

8 ounces water
3 grains permanganate of potash
6 drops sulphuric acid

Intensification. When the shadows of a negative are only gray, either because of too short exposure or too short development, or because of too long exposure and consequent very short development under the sight or factorial system of development, the printing quality of the negative may be improved by intensification by the mercury process, provided always that the negative is not spoiled by the amateur efforts at intensification. Intensification and reduction of negatives should be avoided by mastering the art of exposure.

Reduction. When the entire negative is too dense, use the potash reducer. When the clear portions print satisfactorily but the dark portions are too dense, giving too much contrast in the print, use the permanganate reducer. Except with skill, the negative may be ruined with either. It is well to experiment on a few negatives of small value before attempting either reduction or intensification of a precious picture—and make a few prints from the negative before risking it by intensifying or reducing.

Retouching and Spotting. Retouching consists of working upon the negative, usually with pencils, to improve its quality or to modify the image. First, varnish the negative with a good retouching varnish. Then, working with a fine pencil point, a dark line in the print, as a wrinkle in a face, which shows as a light line in the negative, may be so penciled over that it is much reduced in the print or does not show at all. Retouching is a task which usually requires special training and much skill.

Pin-holes. Small transparent spots sometimes appear in a negative, resembling pin-holes in appearance, due to defect in the gelatine of the plate, to grains of dust on the plate during exposure keeping the light from striking the plate under the dust grain, or to air bubbles clinging to the plate during development. These may be blacked in by a weak solution of India ink applied with a small camel's-hair brush formed down to an extremely fine point. Several applications of a thin color, just touching the spot with the tip of the brush until the film absorbs the ink, will gradually darken the pin-hole until it matches the part of the negative immediately surrounding it.

An opaque spot on the negative, such as might be produced by a grain of dust caught by the film while drying, or by an overspotted pin-hole, will make a light spot on the print, which then may be spotted out upon each print with India ink in the same manner as upon the negative.

PRINTING

Printing consists of transferring the image from the glass negative to a sheet of sensitive paper, and then rendering the paper insensitive so that the transferred image cannot change. This transfer of the image to the printing paper is effected without changing or injuring the negative, and as many finished prints as are desired may be made from one negative.

The negative is not a reproduction of the view, but a record of the image in reversed or "negative" form, with the lights of the view showing dark and the shadows showing light. The print is made from the negative by the use of chemicals which discolor when acted upon by light, giving a shadow in the print where the negative is clear, and a high light where the negative shows dark. The print thus is a "negative of a negative," and shows the view in its proper relation of light and shade.

Processes. Four processes of printing, or producing positive pictures from photographic negatives, are in general use:

(*1*) Printing-out toning processes;
(*2*) Printing-out self-toning processes;
(*3*) Developing or gaslight processes;
(*4*) Enlarging or lens-printing.

In each case, the process consists of subjecting a sheet of sensitized printing paper to the action of light which has passed through the negative, then "fixing" the print thus made.

Printing Frame. The printing frame consists of two parts, frame and back. The frame is open, with a rabbet of proper size to take the glass negative as a piece of glass is placed in a picture frame. The back is in two parts, hinged together, each part having spring clamps for fastening it into the frame. The negative and then the print paper are put in the frame, the back is put on, and the clamps closed. The loaded frame is placed in the sunlight and the printing paper is discolored by the light passing through the negative. By unclamping *one part* of the back and opening it on its hinge carefully, the progress of the print may be observed. The remaining clamped part of the back holds the print paper and the negative in alignment while the free end of the print is looked at.

Printing-out Papers. These papers are so called because the pictures "print out" or become visible while the paper is printing in the sun. The printing paper consists of a sheet of paper with a film on one side, similar to the film of a glass plate, but very much less rapid, or less sensitive to light. In handling it, the red light is not required, as ordinary gas light or the light of an oil lamp does not affect the paper. Subdued daylight, as in a room with the shades drawn, usually is safe and does not affect the printing-out paper.

Chloride Papers. The usual "silver" paper consists of chloride of silver held in a surface of gelatine, collodion, or albumen. It requires the three steps of printing in the frame, toning in a gold bath, and then fixing in hypo, in addition to many wash waters, to produce the finished print ready for mounting upon a card.

To print, lay the printing frame face down, lay the negative in the printing frame with the film side up, lay the piece of printing paper on the negative with the sensitive side down, then a pad of half a dozen pieces of newspaper cut the right size, then put in the back and fasten the clamps. When thus filled, place the frame in the strongest light possible—direct sunlight is best—with the glass side toward the sun. The progress of printing may be watched by looking at one half of the print from time to time, opening the frame and turning back the end of the print, as shown in Fig. 28. This examination must be made in the shade, at least with the frame held in the shadow of the operator's body. Continue the printing until the picture is much darker than desired in the finished photograph. Print until the details in the half-tones have disappeared, indeed until the print seems spoiled. It will fade back in the toning, fixing, and washing to give what is wanted. The degree of over-printing can be learned only by experience and practice.

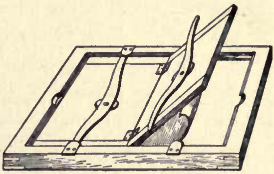


Fig. 28. Printing Frame Open for Inspection of Print

There are many different brands of paper offered by manufacturers, and the explicit instructions which accompany each package of printing paper should be followed. At first, use a toning bath bought ready mixed, if it can be bought especially prepared for the particular paper used. The formulas which follow are representative, and are adapted for most chloride printing-out papers.

Washing before Toning. Place the prints in running water or wash through several changes until the wash water no longer shows milkiness. The silver unaffected by light will be washed out. The prints will get lighter and reddish in color. Keep the prints moving while in the wash water.

Toning. Make two stock solutions.

Gold Solution

$7\frac{1}{2}$ grains pure chloride of gold
8 ounces pure water

or 15 grains chloride of gold and sodium may be used instead of the pure chloride.

Soda Solution

Pure water
Bicarbonate of soda to saturate

By *saturation* is meant to put into the bottle of water all the soda crystals it will dissolve.

For a dozen 4 by 5 prints, shake the bottle of gold and take one-half ounce of the solution and eight ounces of water, place a piece of red litmus paper in it and add the soda solution drop by drop until the litmus paper begins to turn blue. If the litmus paper turns blue too rapidly, add a drop or two more of the gold to slow it. A fresh piece of litmus paper should show slight blue at the end of one minute. This toning bath must be nicely balanced between the gold and soda, and then left for half an hour to ripen before using. Mix the toning bath, and let it ripen while washing the prints. Place the washed prints in the toning bath and keep them moving.

Stopping. The prints will change in color through a range of browns to purple or black. They may be stopped brown or at any shade desired. When any print has reached its desired shade, change it to the stop solution.

Stop Solution

1 ounce table salt
1 gallon water

Fixing. When all prints are toned and stopped, place them in a fixing bath and keep them moving for twenty minutes. The alum fixing bath is preferable.

Soda Fixing Bath

1 gallon water
1 pound hyposulphite of soda

Alum Fixing Bath

1 gallon water
8 ounces hyposulphite of soda, crystals
3 ounces alum, crystals
½ ounce sulphite of soda, crystals
1 ounce borax

Dissolve the borax in a pint of hot water. Dissolve the remaining chemicals in the remaining water, then pour in the borax solution. This bath must be made up the day before it is needed. It keeps indefinitely both before and after using but should not be used after fixing two dozen 4 by 5 prints to the pint.

Final Washing. After fixing, the hypo must be thoroughly washed out or the prints will become discolored with age. Wash for an hour in running water, or for two hours in changing water, changing the water at first every five minutes. To change the water on the prints, use two dishes, lifting the prints one by one from the first dish into the second, with a moment of draining.

Combined Toning and Fixing. Two stock solutions are required, soda and gold.

Stock Soda Solution

8 ounces hyposulphite of soda, crystals
6 ounces alum, crystals
2 ounces granulated sugar
2 ounces borax
88 ounces water

Dissolve the borax in a half-pint of hot water; dissolve the remaining chemicals in the remaining water, cold, and pour in the borax. Let stand over night and pour off the clear liquid.

Stock Gold Solution

7½ grains pure chloride of gold
64 grains acetate of lead
8 ounces water

Fifteen grains chloride of gold and sodium may be used instead of the pure chloride of gold. Do not filter. Shake before using.

For fifteen 4 by 5 prints, take 8 ounces of stock soda and one ounce of stock gold and put in the dry, raw prints without washing before toning. When properly toned, stop them in a solution of 1 ounce of salt and 1 quart of water. Then if possible use the acid fixing bath for ten minutes to ensure thorough fixing. Wash finally for an hour in running water, or the equivalent in changing waters.

The formula given for the combined toning and fixing bath is a thoroughly tested one, and may be bought ready mixed under the name of "Solio Toning Solution."

Self-Toning Paper. These are printing-out papers which take a brown tone without the use of the gold toning solution. Their manipulation is much simpler than the ordinary printing-out papers. Some of them require only washing in water to tone and to render the print permanent. Others require a hypo solution, but in all instances the claim of self-toning is justified by the simplicity of the operations required after printing.

Blue Prints. When purchased, the blue print paper has one side coated with a sensitizing solution containing iron. The coated side varies from a light yellow to green in color. When printed under a negative in a printing frame in the sun as with any other printing-out paper, the image comes up a dull dark blue and the shadows change to a gray or bronze appearance. Print until the deep shadows are bronze and until the detail is lost and the print seems spoiled. Then wash in clear water until all the yellow is washed out of the print and dry. Too long washing will lose the details and half tones of the picture. The picture is blue and white, and is permanent.

Sepia. Print as for blue prints, but develop in a very weak solution of hyposulphite of soda before final washing. If the hypo is too strong, the prints will fade in the bath. The sepia print must be placed in the hypo and then in the wash water instantly when removed from the printing frame; it will not "keep" even a few minutes.

Developing Papers. The amateur who is employed during the day will find his time best disposed and will get the most enjoyment out of his photographic occupations by using his holidays in the field with his camera making exposures for new negatives and by making his prints by artificial light in the evenings. The printing papers which are offered for contact printing by artificial light are substantially slow plate films spread upon paper supports. The processes of exposure, development, and fixing are substantially the same. Pyro cannot be used. The hydro-metol formula for developer for plates and the fixing baths either plain or acid are proper for developing papers. The acid fixing bath is preferred. Visual development is entirely satisfactory and factorial or tank development need not be attempted. With normal working and a normal negative, a finished print is in the fixing bath in less than one minute after the negative and paper are put in the printing frame, giving a decided advantage for the amateur over the slower processes of printing-out papers.

The sensitive coating of developing papers is made much slower in response to light than the coating used for plates, so much so that red light is unnecessary. The developing trays may be placed upon a table 6 feet or more from a gas jet, but when developing the operator should stand with his back to the gas jet and with the shadow of his body falling over the developing tray. The paper should be kept covered or wrapped in black paper before printing, and should be loaded into the printing frame in the shadow of the operator's body.

The printing outfit required consists of a printing frame, Fig. 28, and three developing trays. Place the three trays in a row, developer in the left, water in the middle, and fixing bath in the right. The trays are very convenient if of a larger size than the prints to be made, and the quantity of solutions contained must be liberal. Each print passed through the developer consumes some of the strength of the solution, thus weakening it, and if the quantity of the developer is small the print may weaken it to such an extent that two prints from the same negative and having the same exposure will develop differently because of the weakening of a small quantity of developer by the first of the prints. A developer may be used repeatedly until it becomes too slow in action.

Developing papers may be printed by exposing the loaded printing frame to daylight, but daylight is so variable from minute to minute, if there are clouds in the sky, that an element of uncertainty and, therefore, an element of failure is brought into the operation of making the prints. Artificial light usually is constant and is preferable for that reason. With a 4 by 5 printing frame, loaded with a medium negative, and held 7 inches from an ordinary gas or incandescent electric lamp, a trial exposure of twenty seconds may be made. Remove the paper from the frame—it shows no image—and immerse in the developer. In fifteen seconds it should be completely developed, and unless transferred quickly to the water it will be over-developed. Rinse for a few seconds in the water to remove the developer from the surface and place it in the fixing bath. After fifteen minutes in the fixing bath, wash and dry. To be able to stop the development at the proper instant upon an over-exposed print, lift the print when development is nearly complete and let the developing solution drain back into the tray. The print will continue developing for a few seconds while held in the air, because of the developer which clings to the surface. At the proper instant, plunge it into the wash water, which will stop development almost instantly, and then into the fixing bath. Turn an under-exposed print face down in the developing tray to avoid fog during prolonged development.

If with a proper exposure the whites of the picture are gray before the shadows are deep enough, the addition of a few drops of a solution of bromide of potassium—1 ounce bromide of potassium dissolved in 10 ounces water—will tend to keep them clear. Too much bromide in the developer will give olive tones to the print. Old and slow developer will give purplish tones to the print. Fresh normal developer, without too much bromide will give pure blacks and whites with untinted half tones throughout the entire range from light to shadow.

The time of development should be about fifteen seconds with normal developer, average negatives, and regular qualities of developing papers. The amount of exposure should be gauged to require this time of development. The length of exposure may be regulated to some extent by the distance between the light and the printing frame. Double the distance for the same negative requires four times the length of exposure, and half the distance requires but one-quarter the length of exposure, but if the printing frame is brought too near the light the center of the picture will be printed darker than the edges and the heat may crack the glass negative. If the length of exposure is shorter than twenty seconds, increase the distance from the light and give a longer exposure. It is very difficult to time accurately an exposure of less than twenty seconds, and by adopting a longer exposure the proper length may be given more accurately. The adjustment of exposure by distance also involves printing a thin negative by weak light and a dense negative by strong light, a rule usually recommended by the makers of gaslight papers. To secure uniformity of illumination over the entire negative, a 4 by 5 frame should not be exposed closer than 7 inches from the light, and a 5 by 7 frame not closer than 10 inches.

Several different brands of developing papers are to be bought in the market, all differing from each other to some extent, and for each brand the manufacturer advises a specific treatment, developer compound, etc. The instructions with the paper should be read carefully until understood.

Lens Printing. In a contact print, the images of the print always are of the exact size of the images in the negative; it is not possible in a contact print to make a print larger than the negative, and it is possible to make a print smaller than the negative only by omitting some portion of the view, such as the margins, the images actually printed being of the size of those of the negative. By printing through a lens it is possible to change the size of the images of the picture, producing a print either smaller or larger than the negative from which it is taken.

Printing through a lens is a process requiring longer exposures or more sensitive printing paper than contact printing, since all

FOOD FOR THE HUNGRY
Scene from Photoplay, "How He Redeemed Himself"
Courtesy of the *Champion Film Company, New York*

SCENE FROM PHOTOPLAY, "THREE OF A KIND"
Courtesy of *Independent Moving Pictures Co., New York*

the light which may fall upon the negative cannot be passed through the negative and lens effectively to act upon the print paper. To bring the time of exposure within reasonable limits, a paper called *bromide paper* is used. This is much more sensitive to light than the brands used for contact printing. When arrangements are made to illuminate the negative by daylight, the use of bromide paper will bring the exposures frequently to less than one minute in length. The length of exposure will depend upon the size of the enlarged picture, as well as upon the size and density of the negative, the diaphragm stop of the lens used, and the intensity of the light.

Bromide paper cannot be handled in daylight or in gaslight, as ordinary developing papers are handled, but must be worked in the darkroom. It is developed and fixed as the ordinary developing papers are, the developing and fixing formulas given for the developing papers being in general suitable for bromide papers, but in the case of the bromide papers the instructions accompanying each brand of paper should also be studied until understood, and if possible the exact formulas which accompany the paper should be used in working the paper. The manufacturer has done all the experimenting necessary to produce good results.

Enlargements. To make an enlargement, a window must be closed with a tight screen having a hole in it a little larger than the negative, and at such a height that the camera may be backed up against the hole to close it. A cloth thrown about the camera when thus placed will seal the window light tight. Cut the middle partition out of a double plate-holder so that when a negative is placed in the plate-holder it will be held by the edges only. Remove the ground glass from the camera, place a negative in the plate-holder and place the plate-holder in the camera. Place a white screen vertically in front of the camera, and focus the negative upon it by racking the front of the camera out to the proper focus. To make the image upon the screen larger, move the screen farther from the camera; to make the image smaller, move the screen nearer to the camera. If the window does not open directly to the free sky, a mirror may be placed outside the window to reflect the free sky into the negative. The arrangement with mirror is shown in Fig. 29. The only light entering the room is that passing through the negative and the lens.

To make a test exposure, place a piece of ruby glass in front of the lens and tack upon the screen a strip of bromide paper. Remove the ruby glass from the lens for one-half minute and cover one-quarter of the strip of bromide. Again remove the ruby glass from the lens for one-half minute and then cover the second quarter of the bromide strip, which now has had one minute. Remove the ruby glass from the lens for one minute and cover the third quarter of the bromide strip, which now has had two minutes. Remove the ruby glass from the lens for two minutes, giving the remaining

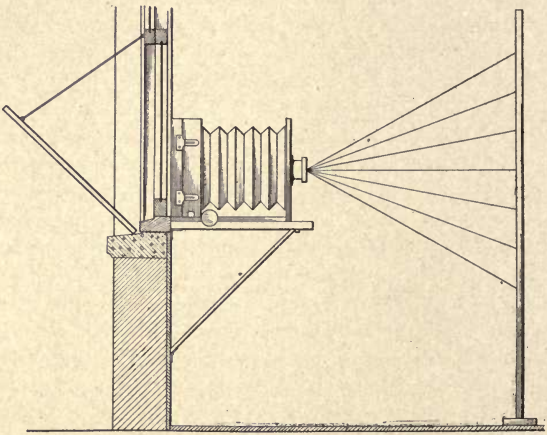


Fig. 29. Camera Arranged for Daylight Enlarging

quarter of the bromide strip four minutes in all. Develop the strip, and it will tell which exposure is correct, or between which two values the correct time will be found. When this is known, tack a full-size piece of bromide paper on the screen and expose for the determined length of time, developing, fixing, and washing the resulting print.

Lens caps fitted with ruby or orange glass may be bought for capping the lens while pinning the bromide paper to the screen for exposure. The advantage of such a colored glass cap is that it leaves the image visible upon the screen and the bromide paper may be correctly placed. This is of particular value when only a part of the whole negative is to be printed in the enlargement.

SPECIAL APPLICATIONS OF PHOTOGRAPHY

Lantern Slides. To tell a long story in a short way, the lantern slide is a print on glass instead of on paper. Lantern-slide plates are sensitized usually with the same chemicals used in bromide paper. They may be printed by contact printing as any developing paper is printed, or may be printed by lens printing. In either case, they must be handled by darkroom methods, because they are as sensitive as the bromide paper and nearly as sensitive (about one-twentieth) as the dry plates used for negatives.

The American lantern slide is always of a standard size, $3\frac{1}{4}$ by 4 inches. Foreign slides sometimes have other dimensions. Upon this size of plate, the actual picture for projection by the lantern seldom is larger than $2\frac{3}{4}$ by $2\frac{3}{4}$ inches. Where the image to be printed upon the lantern slide is contained within this space in the negative, the slide may be printed by contact, but where the image in the negative is larger than 3 by 3 inches, it will be necessary to employ the process of lens printing. As the lantern slide is but a bromide print on glass, all of the instructions for lens printing on paper apply directly to the making of a lens-printed lantern slide. The lens printing of the lantern slide will be necessarily "copying down" or reducing rather than enlarging, meaning that the screen upon which the picture is focused will be closer to the lens and will require a longer draw for the camera bellows. If necessary, a box with both ends open may be introduced against the window, holding the negative against the window, the back end of the camera being against the other end of the box, thus providing an extension to the length of the total draw obtainable by the box and the bellows together. Correction for the thickness of the glass of the lantern-slide plate must be made to secure proper focus, but a ground glass may be focused upon and the slide plate substituted for exposure.

Another method of lens printing for lantern slides when the reductions are considerable, is to place the lantern-slide plate in the plate-holder of the camera, place the negative in the window, and focus the ground glass of the camera upon it with the lens end of the bellows toward the negative, inserting the lantern-slide plate with the dark slide and exposing as in a field exposure, thus actually making a photograph of the negative.

Place a lantern-slide mask upon the completed glass print, place a cover glass over it, and bind the edges with lantern-slide binding strip, and the slide is finished.

Stereographs. These double pictures are adapted to present two slightly different images of the same object to the two eyes when viewing the stereograph, the two images being different in just the details wherein the two eyes of the observer would see the physical object differently by reason of the difference between the viewpoints of the observer's eyes. The two pictures of the stereograph are made simultaneously by a camera having two lenses side by side. A two-image negative thus is produced, a two-image print is made from it, and the two images are cut apart and pasted upon a card for viewing through the lenses of the stereoscope. By reason of the lens reversal of the images in the camera, the images of the print must be transposed before pasting upon the card. The distance between the lenses usually is about 3½ inches; between the prints on the stereograph mount, about 2¾ inches. This gives a slightly exaggerated perspective, increasing the illusion of perspective and solidity when the stereograph is viewed properly. While the paired lenses are desirable, stereographs of still objects or scenes may be made by an amateur by two successive exposures of the same camera, the camera being moved 3 or 4 inches between the two exposures. Use a small lens stop, as great depth of focus is desirable in a stereograph.

Panoramas. The ordinary photographic lens places upon the ground glass an image which includes about sixty degrees of the horizon. *Wide-angle* lenses are lenses of short focus for comparatively large plates and sometimes cover one hundred degrees or more. Negatives including more of the horizon than any single fixed lens can make have been obtained by a swinging lens. A camera of this nature has a sensitive film held in a semicircle, and has its lens mounted in a swinging frame which gives an exposure of but a narrow vertical slit upon the film. As the lens swings, nearly one-half of the horizon is impressed upon the film in a continuous image. Another type of panoramic camera has gears for revolving it upon the tripod top and winds a roll of film behind the slit of a lens while the camera is revolving. With this camera an image may be made including the entire horizon.

Panoramic prints may be made by the amateur by making two or more plate exposures and pasting the prints upon a card with the edges carefully trimmed and matched. In making such exposures intended for panoramic mounting, the vertical line of matching should be in mind when arranging the image upon the ground glass. Only the double lens should be used, as the distortion of the single lens will be seen when the edges are matched in the finished picture.

Telephotography. Quite the opposite of panoramic photography is telephotography, which is the art of enlarging a small portion of the view to fill the entire plate. The production of a large image of a distant object is the result which telephotography en-

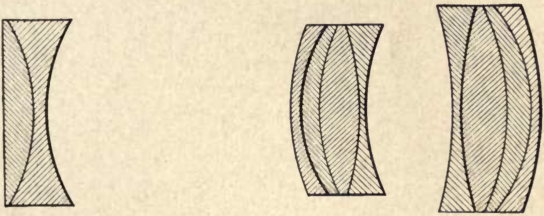


Fig. 30. Glasses of a Telephoto Lens

deavors to obtain. This is done directly in the camera by adding a third lens cell to the double lens; a negative cell, having a lens thinner in the middle than at the edges, spreads the middle part of the image to cover all of the plate. The arrangement of glasses in such a lens is shown in Fig. 30. The third, or negative, lens is mounted at the back end of a long lens tube and an ordinary double lens is mounted at the front. By the use of the telephotographic lens, a bellows extension of 12 inches may be sufficient to make an image upon the ground glass as large as would be made by a lens of 48 or 60 inches in focal length. The time of exposure, however, is proportionately longer, and the enlarged image upon the ground glass is proportionately dim. Telephotography is a process for the enlargement of the image in the camera before it is recorded. The result does not differ from an enlargement made from a small portion of a negative taken from the same viewpoint, unless in greater sharpness of detail.

Orthochromatic Photography. White light is made up of a mixture of colors, and colored objects are objects which separate the white light which falls upon them and give to the eye but a part of its component colors. Of all the visible colors, the blue and violet are the most active in affecting the photographic plate. There are also invisible rays, called *ultra-violet* rays, accompanying white light which are very powerful to affect the sensitive plate. With the blue light more powerful in action upon the sensitive plate, it is clear that when an exposure is made upon a subject containing blue, yellow, and red, as a bouquet of flowers, the light from blue blossoms will make a darker image in the negative and, therefore, a lighter image in the print than light from the red or yellow blossoms. Thus, a scene having colors will not be reproduced in its proper light and shadow values by the ordinary processes of amateur photography. A rosebush in bloom with white roses will give proper results, but an adjacent bush in bloom with red roses will appear in the photograph to have no blossoms at all, since the bright red of the blossoms is no more effective upon the sensitive plate than the dull green of the rose leaves, and the roses may be distinguished upon the bush only by their shape, as green apples upon a midsummer tree.

To remedy this feature of the ordinary photographic processes and to render photography suitable for colored objects, a plate sensitive to yellow and slightly sensitive to red is made, and there is made also a colored screen, or "ray filter" for the lens which has the faculty of holding out a large portion of the blue and ultra-violet rays and permitting all of the yellow and red rays to pass. When such a plate, called an *orthochromatic plate*, is exposed to a lens image of light which has passed through a proper ray filter, the blues, yellows, and reds will all have equal effect upon the plate, and the resultant picture will show the view, not in colors at all, but in proper values of light and shade regardless of color in the view. The objection to the universal use of the orthochrome plate and the ray filter is that from three to eight times the exposure is required.

Colored Photographs. Any print may be colored by brush and suitable transparent dyes. If it is the wish to reproduce the actual colors of the scene, it is necessary that the negative be made with an orthochromatic plate, or it will be impossible to reproduce the reds, since they will be black in the print. Photography in natural colors by camera and development processes without recourse to hand coloring is a problem which has been solved in several ways, yet no solution is entirely satisfactory. The most nearly satisfactory processes involve *first*, the separation of the light of the image into two, three, or four different colors; *second*, the photographing of the separate colors by separate negatives, the negatives being uncolored; *third*, the making of prints, one for each negative and each print of a single color in itself but of a color different from the other prints of the set; and *fourth*, combining the separately colored prints or arranging them in a viewing device such that all of the prints may be viewed at once. The colors, thus being placed upon each other, blend in the eye to form all the hues of the original view.

Tri-Color Photography. Pieces of orange-red, green, and violet glass are required, of such size as to cover the lens of the camera. Tri-color results will largely depend upon the accuracy and purity of the hue of these colored ray filters. Having selected and focused the scene, expose three orthochromatic plates, one after another, each of them with one of the colored glasses in front of the lens. With a set of color filters used by the author, the exposure required is four times normal with the violet filter, thirty times normal with the green filter, and five hundred times normal with the orange filter. The negatives when developed will all look alike. Make three lantern-slide plates and cover each with a cover glass of the color through which the negative of that slide was made. In all slides, white objects are clear glass; shadows are black. Brightly colored objects remembered in the view will have different half-tone values in the three plates. A violet object is lightest in the violet plate. A blue object is darkest in the orange plate. A green object is lightest in the green plate. A yellow object is darkest in the violet plate. A red object is lightest in the orange plate. The three slides are projected by three lanterns upon the same screen and at the same time, when the colors will unite to give all the hues of the original view. The process is simple in theory, but requires very careful and accurate working to produce acceptable results.

Autochrome Plates. By the use of these plates an amateur may make pictures in natural colors as simply as making a negative and paper print. Each exposure in the camera produces not a negative but a glass positive print in colors, suitable for direct view or for lantern slide if of proper size. The exposure is made through a special orange screen, and the time of exposure is about one hundred times the normal exposure for the same view and lens stop with ordinary plate and no ray filter.

Autochrome plates differ from ordinary plates by having interposed between the sensitive coating and the glass a thin layer of transparent microscopical starch grains, dyed orange-red, green, and violet, spread without over-lapping, and mixed in such proportion that the layer appears colorless. The sensitive coating is extremely thin, and made of a very fine-grained emulsion. When such a plate is exposed in the camera, the glass side toward the lens, the light before reaching the sensitive coating passes through the colored starch grains, which act individually as minute color filters, each one absorbing all colors but its own. A microscopical selection takes place, and after development there will be found under each grain a corresponding black image of a density proportionate to the amount of color received and transmitted by this particular grain. Were the plates fixed at this stage, the picture when examined by light passing through the plate would show only the colors complementary to those of the original, since the true colors are masked by the black images they created beneath the grains. The next step is to dissolve the black silver by an acid permanganate solution; then the plate is exposed to white light and re-developed, blackening the white silver left by the permanganate solution. The image now is reversed. Each color grain transmits light precisely of the same hue and proportionate intensity as the light transmitted by the grain when the exposure was made in the camera, and the view is seen in its natural colors.

SCENE FROM PHOTOPLAY, "THE ROSE OF OLD ST. AUGUSTINE," OR "A TALE OF JEAN LAFITTE, THE PRIVATEER"
Courtesy of *Selig Polyscope Co., Inc., Chicago*

SCENE FROM PHOTOPLAY, "VAN BIBBER'S EXPERIMENT"
Courtesy of *Thomas A. Edison, Inc., Orange, N. J.*

MOTOGRAPHY

Motography, or motion photography, is compared with fixed or still photography at every point. It is contrasted with fixed photography in three important phases: *First,* the product desired; *second,* the methods of production required, which involve the author of the film story and the producer, with their assistants; and *third,* the means adopted, which involves the photographer and his specialized photographic equipment.

PRODUCT DESIRED

Fundamentally, motography is the art of depicting motion by means of photography. Usually the associated step of projection is used for viewing the motion depicted in the motion-picture film, but with this the photographer of the motion picture is hardly concerned. His picture when completed may be viewed by projection, or by direct vision in a proper stepping device, or by close and careful study of the successive pictures, either alone or with two consecutive pictures placed over each other to reveal the differences due to motion in the subject. Motion pictures may be made for scientific study or for purposes of amusement.

Chronophotography. In this word, "chrono" means "time," and the object of the art of chronophotography is to photograph the condition of a moving subject at successive times in its movement. Such a process would produce if possible a sharp photograph of the subject at regular intervals, so that a careful study of the series of pictures might reveal just what changes had taken place in the short interval of time between the taking of two successive pictures. The extreme positions taken by the subject and the positions of the subject at critical instants may be observed in such a series of pictures, enabling a scientist to study his subject in a manner that is hardly possible by any means other than chronophotography.

Chronophotographic machines have been devised to make pictures at a rate as fast as five hundred pictures of the same subject in one second. With a flying bird beating its wings at the rate of two beats per second, such a photograph would present two hundred and fifty different positions of the wings of the bird in beating the air, and certain of the images would show the extreme upper, the extreme lower, and the extreme outward positions of the wings, as well as showing the difference in positions of the wings in beating downward upon the air and in returning to the upper position. These photographs should be sharp and distinct as far as possible, that even the details of the wing feathers may be studied. Such a series of photographs should be of value to a student of flying machines, but it is not recorded that any such good has come of it.

In the study of a walking man, chronophotographic studies have been made by the military department of France and, as a result of those studies and experiments conducted in connection with them, it has been found possible to increase the endurance of infantry on march by teaching the soldiers an improved marching gait.

In chronophotography, it is desired to photograph the subject *as it is* rather than as the eye sees it, for because of its motion the eye of the observer may be deceived as to the actual positions taken and as to their actual order of occurrence. It is the object of chronophotography to reveal for the study of the scientist that which the eye is unable to see.

Kinephotography. This is an older name for motography. In this word, "kine" means "motion," and the object of motography is to make a record of the motion of the subject in such a manner that by the use of the record the motion may be reproduced to the eye viewing the picture.

In motography, it is desired to photograph the subject *as the eye sees it* rather than to reveal it as it is, and if because of the motion of the subject the eye is in any way deceived when viewing the physical subject, then the true artist motographer will produce such a picture as will also deceive the eye in the same way and to the same extent when viewing the motion picture.

The making of motion pictures is thus divided into two classes: motion pictures for scientific study—chronophotography; and motion pictures for amusement—motography—for motography is so largely an industry of amusement that its other phases may be considered as subordinate. Chronophotography will be considered later as a subordinate phase of motography.

Subjects. Primarily the proper subject for a motion picture is motion, or a subject containing motion. This is not a limitation, however, for still subjects are very forcibly presented in motion pictures when the camera itself has movement so that each of the successive images upon the film is made from a different viewpoint.

Subjects are classified in the trade as travels, industrials, current events, dramas, comedies, and trick pictures. Travels, industrials, and current events, are pictures in which the motographer finds his subject ready for his camera. It is necessary only to choose a viewpoint for the camera, and to choose an opportune moment, particularly for proper lighting, or if an interior is involved it may be necessary to provide artificial lighting. Dramas, comedies, chases, and trick pictures on the other hand are classes in which the motographer must create his subject. These form the bulk of the film industry and occupy the picture screens of the motion-picture theaters almost exclusively. These classes overlap each other, while science studies are a class apart. In many instances, a film picture might be classified in either of two or even more classes, according to one's own judgment.

Travels. Travels include pictures showing the natural scenery of the country as the chief interest of the picture. The title takes a form indicating a journey or a visit to a country or place. The film is made up of many scenes, as though the motographer were enjoying a holiday with his camera and were photographing everything of interest to him, particularly everything typical of the place or country in which his visit is made, or of the line of travel over which his journey carries him.

Industrials. Industrials are in substance similar to travels, the distinction being rather that the one takes the work of man as a subject and the other takes the work of nature. An industrial picture shows the production of something involving the industry of man. Factory industries when made the subject of motion pictures may include the production in the mine, farm, or forest of the raw material; views of the machinery with which the raw material is worked through its various stages of manufacture; views of the material itself in its successive stages of manufacture; and views of the finished product. Mining, farming, lumbering, and shipping, when made the subject of industrial motion pictures, verge upon the classification of travels. A decision as to whether the picture should be classified as travel or industrial should be based upon the manner in which the motographer has handled his subject.

Current Events. Current events are substantially news pictures. Whether an event of interest becomes a part of a travel picture, an industrial picture, or a current-event picture comparable to a newspaper illustration, depends largely upon the manner in which it is handled. "A Visit to London" (travel) may properly include views of water sports on the Thames; "The Ice Industry" (industrial) may open with a scene of skating on the ice and close with spectators consuming ice-cold beverages while they watch a tennis game; a professional ball game or a prize-fight seems "industrial" within itself; "The Funeral of King Edward VII.," a splendid and impressive film, is properly classified as a news picture (current events).

Dramas. Dramas are pictures which have a story to tell. They are comprised of a series of connected incidents which tell the story step-by-step—as a staged production in pantomime—yet do not contain the element of levity or burlesque to such an extent as to render the film classifiable as a comedy. The main object of the drama is to tell a story in a pleasing manner and in such a way that the story forms the fundamental feature of the entertainment, and not the actors, nor the stage setting, nor the separate incidents.

Comedies. Comedies are pictures which are designed to tell a story with the sole intent of creating laughter. When in the nature of drama, the plot and its execution by the actors is light or burlesque in nature. Pictured jokes, pictured puns, pictured accidents with ludicrous results, awkwardness and confusion on the part of the actors, all furnish subject matter for this class of film pictures.

Chases. Chases are a division of the comedy class, in which the story involves the pursuit of some of the actors by others. A long series of ludicrous incidents may be strung together in a film, depicting the efforts of the pursued to evade his pursuers and the tribulations of the pursuers, ending the film either with or without a capture.

Trick Pictures. Trick pictures are based upon the ability of the motographer to deceive the audience with film pictures produced by special manipulation of the motion-picture camera. Trick pictures usually are comedies in that the trick-picture art usually is used to produce laughter. Under this class, however, come pictures of transformations forming parts of more serious dramas, and some trick pictures themselves are wonders of illusion so profound that they have a charm of their own and offer a class of entertainment neither drama, nor comedy, nor chase, and classifiable only as "trick" or "spectacular."

METHODS OF PRODUCTION

Early Methods. *Drawn Pictures.* Motion pictures are almost as old as pictures, but until the advent of photography the motion picture was nothing but a scientific curiosity or a toy. The oldest motion-picture device of which we find record is the *zoetrope*, Fig. 1, a whirling device having a number of slits in a cylinder, and opposite each slit a picture. As the cylinder whirls, the pictures are seen in rapid succession, and the whirling may be so rapid that the pictures seem all piled upon each other. When the device is turned at proper speed, persistence of vision holds one picture until the next is seen. By drawing the pictures by hand, taking care to simulate successive positions of an object, the object will seem to have motion when the device is whirled and the pictures are seen successively.

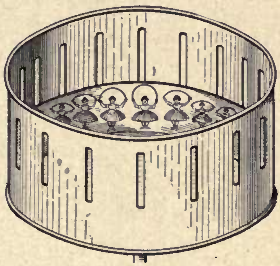


Fig. 1. The Zoetrope

Since the advent of the first picture-viewing device and before the advent of photography, a large number of designs of viewing or even of projecting apparatus for motion pictures had been produced, but no devices for making the pictures to be viewed. The making of the many pictures by hand was a well nigh impossible task. In such a series, the fixed objects must be exactly alike in all of the pictures of the series or there will seem to be motion in the fixed things of the picture. The moving objects must be similar in all details and must vary in position only, and the variation in position must be in harmony throughout all the moving objects of the scene. A compromise was effected by one progressive experimenter, who projected his fixed objects from a fixed lantern slide and projected upon that fixed scene his carefully drawn moving images. In this way he simulated the entrances, gestures, and exits of actors upon a stage setting, and in the light of more modern history it is but reasonable to think that perhaps he supplied also spoken words for the actors, thereby anticipating in a measure the modern "talking pictures."

Photographic Process. With the discovery of photography came the realization that here was a new agent for the production of pictures for the moving-picture exhibiting apparatus. The difficulty to be met was in photographing moving scenes with photographs taken in such quick succession that the movement between two successive images would be so small that the two images would seem to blend into one as the hand-drawn pictures of the zoetrope did when the new photographs were substituted for the old hand-drawn images.

Separate Cameras. The first solution was by Muybridge who, in 1877, arranged a row of twenty-four cameras with string-trigger shutters, the string of each shutter being stretched across a race track. A horse rapidly driven down this race track broke the strings and released the shutters as the horse was opposite each camera, thus taking a series of pictures within a very short period of time. When these plates had been developed and compared and matched up, it was found that a set of them could be arranged to show the successive positions of the running horse. This set comprising only a limited number of images was suitable to be shown in any of the motion-picture viewing devices then known.

Multiple Camera. The next solution was that of LePrince, about ten years later, who arranged a multiple camera. This, in substance, was a battery of sixteen automatically reloading cameras, using strip film. Each camera would make one picture and while the remaining fifteen cameras were making fifteen more pictures in regular sequence, the first camera would automatically bring a fresh film into position to make the seventeenth picture in its turn, and so repeatedly the sixteen cameras would operate to make a con-

THE OUTLAW MAKING HIS GET-A-WAY
Scene from Photoplay, "The Outlaw and the Child"
Courtesy of *Essanay Film Mfg. Co., Chicago*

HE'S MY SWEETHEART
Scene from Photoplay, "In the Great Big West"
Courtesy of the *Champion Film Company, New York*

tinuous series of photographs. This LePrince camera was the immediate ancestor of the modern motion-picture camera, being built in a single case with battery of sixteen lenses and sixteen shutters, all operated by a single continuously turned crank. The pictures were taken upon four strips of film. By printing four positive strips and passing them through the same battery of lenses and shutters, projection could be accomplished, or the pictures could be cut apart and pasted into a single strip such as is used in a modern projecting machine.

Modern Methods. The features of the modern motion picture which are improvements upon the earlier forms and which render it adaptable for its present amusement purposes are the production of the images by photography; the flexible negative film which permits a large number of pictures to be taken quickly in succession upon a single strip of negative record; the transparent support for the positive print or positive film, permitting the picture to be projected in an enlarged scale upon a screen so that it may be viewed by large audiences; and the system of registering holes in the margin of the films by which registry or alignment of the numerous pictures of the series is attained in the projecting machine.

Motion pictures were fully reduced to a commercial entertainment means when it was possible to take a motion camera and a reel of negative film, to select a subject and expose the film upon the subject, to print the negative upon a strip of positive film and produce a positive print, and to project that print upon a picture screen to be viewed by an audience. They were well received by the public from the beginning, and the industry grew rapidly from the first.

In the beginning it was sufficient to photograph anything with movement, and the wonder of the projected picture was sufficient to hold the attention of the audience. A railway train passing, a fire engine, a waterfall, or the view from the car window was sufficient. The subjects, which were confined to "travel" and science studies, and occasional comedies, were enthusiastically received by the public. Dramas were not known.

With the advent of the exclusively motion-picture theater, the demand for drama and comedy grew. It became necessary for motion-picture manufacturers to acquire studios suitable for staging drama and comedy, to employ writers to furnish themes for motion-picture plays, to employ actors and stage directors to present the themes properly before the motion camera, and to employ scene painters and property men in a manner very similar to the operation of a standard theater except that the seating capacity is absent and the play is produced but once in the studio.

Division of Labor. When an industry has reached such a magnitude that many people are employed in its work—Pathé Frères have more than five thousand employes in France—some employes will develop greater ability in some lines than in others, and the lines of activity become so divergent that they are best cared for separately. As in any manufacturing industry, the manufacture of motion-picture films for exhibition in a modern factory has its division of labor, and a film picture is the joint product of the various departments and specialists who in turn take it and perfect it with their skill. Four widely different classes of ability are involved, represented by four men, the author, the producer, the salesman, and the photographer, with their assistants.

The author's stint begins with the conception of the thought and continues until the thought is reduced to motographable form. The "producer" takes charge of the total task at that point and carries the work forward until the motographic scenes of the picture have been recorded upon the sensitive film by the photographer. The photographer's duty comprises the carrying of the camera to the producer's scenes wherever they may be, recording the scenes photographically, developing the negatives, and printing as many finished pictures as the salesman may require. The salesman most likely will be called the advertising manager of the film manufacturing company, but his ultimate duty is to sell the film product which the author, producer, and photographer have worked together to make.

THE AUTHOR

For the production of travels strictly, as travels were produced in the early days, perhaps no author is required. The modern tendency toward drama has modified the custom. It is in dramas, comedies, chases, and trick pictures that the author becomes prominent, and as these form the bulk of the motion-picture industry the author is always first to be considered. Much special training is necessary to become a successful motion-picture author.

His Problems. *Limitations of the Art.* The limitations of the producer must be understood fully by the author. Few fiction writers create a successful drama for the histrionic stage at the first attempt, and their failures are due largely to a lack of knowledge of the limitations, of the technique, of the dramatic stage. Much more limiting are the requirements of the motion-picture producer with his studio stage and voiceless actors.

Many ambitious writers have submitted stories to the film manufacturers in the hope that they might be found suitable for production in motion pictures, but very few of such stories are acceptable. The film manufacturer is still obliged to create his own plots, to write his own stories and scenarios, and to employ persons who have become trained to authorship under the limitations exercised by the producer and the tools he has to work with. Any limitation upon the maker of the film must of necessity be also a limitation upon the writer of the story which is to be told by the film. One limitation is the matter of color, for, unless the story is to be written especially for color production, no essential part or feature of the story or action may depend upon color. Another limitation is time of action, with an upper limit of twenty minutes or one reel of 1,000 feet of film for drama, and usually ten minutes or a half reel of film for comedies or trick pictures. Other limitations are the size of the stage which may be used, the costumes, stage settings, and stage properties, and last and most important of all the necessity of conveying thought by action, gesture, and facial expression rather than by voice.

Plot. The author must deliver an acceptable plot. The proper plot for a motion picture is one suitable for a short story of one thousand words in the current magazines rather than one suitable for a popular novel. The complete action must occur in twenty minutes, and this compels the story to be told as a short story, no matter how much there is to tell. The masterpieces of motion-picture drama consist of simple stories, simply told. The rule carries into comedy, trick, travel, and industrial pictures. A central thought forms the foundation of the story; this is embodied in a series of incidents involving as few leading characters as possible, for it is confusing to the audience to be obliged to carry too many characters in mind. An unnecessary character only confuses the spectator and leads the attention away from the principal characters and from the central thought which they are to give. The series of incidents should require as few stage settings as possible, for the same reason that multiplicity leads to confusion and confusion is undesirable. The time is short, twenty minutes, and the real story of the play must be told fully and plainly, not smothered with unnecessary scenes or incidents nor obscured with side thoughts. Lubin's "Woman Hater" offers a twenty-minute picture of a thousand feet of film staged with a single stage setting and only four characters, and it is one of the masterpieces. Essanay's "Justified" does the same with only three characters and a couple of supes.

The plot is brief. It is only the central idea, the skeleton, the foundation. The title is not the least in importance, for it is the part which is advertised outside the theater and the detail upon which dependence is placed to draw the patrons from the sidewalk past the ticket window into the house. When a striking title is created in the author's mind, the plot is half written.

Scenario. The scenario elaborates the plot into "dramatized" form, for the motion-picture play should be written as if for the stage, not in "fiction" form as for a magazine article. In the scenario, the characters are listed, the required scenic settings are listed, and the action scene by scene is recited. "Titles" are given in the order in which they are met from scene to scene. Under the name of "titles" are included notes written, .newspaper pages, or any matter which the audience must read in the progress of the picture.

SPECIMEN DRAMA SCRIP

The following typical drama with but four leading characters was produced by the American Biograph Company. The scene settings are simple, only three scenes being set for studio, and those not requiring anything unusual in the way of scenery. The outside scenes are such as may be found in any village. That one scene setting is used several times and the total number of scenes thus increased is not objectionable. The plot will withstand successfully a rigid analysis. The drama is divisible into four chapters, as the four acts in a staged play, each chapter having a definite part in the progress of the telling of the story. No scenes of crime or violence are involved, and no scenes of a nature to depress the spirits.

TITLE

A Midnight Cupid

PLOT

A tramp wanders into a club man's rooms and falls asleep. Club man, bored with society, finds tramp and finds in tramp's pocket letter asking tramp to return home. Club man for diversion assumes tramp's identity and goes to his home. Falls in love with tramp's childhood playmate. Tramp returns home. Club man, ousted in disgrace, elopes with girl. Pursued by girl's father. Overtaken in club man's rooms after marriage. Girl's father sees wealth and social position of club man and forgives.

SCENARIO

Cast of Characters

Club man (C M)
Tramp (T)
Girl (G)
Girl's Father (G F) as farmer
Policeman
Two servants to club man
Guests at reception
First farmer
Second farmer
Grocer
Minister
Lady, well dressed, age 40
Two or three men, well dressed
Children

Scene Sets

Club man's rooms (Studio)
Parlor (Studio)
Interior cottage bedroom (Studio)
City park (two sets)
Outside village store
Outside village cottage
Village street
Field

Synopsis

CHAPTER I. Prologue, giving the conditions under which the true action of the drama is to occur.

SCENE 1. *City park, first set.* Discovered, T reading letter.

Title: "Dear Joe: As the father of the girl who was your childhood's sweetheart, I ask you to come back home. (Sig.) Wm. Broadhurst."

(*Back to Scene 1.*) T reads letter sorrowfully, searches pockets, no money; puts letter in upper outside coat pocket with edge visible; lies on bench, sleeps.

Enter policeman, raps T on foot with club, "Move on." Exit policeman left. Exit T right.

SCENE 2. *CM room, well furnished, table, chairs, sofa; door back, door right.* Discovered, CM opening mail. Bored look. Enter servant, brings full decanter, places on table; CM looks at decanter in disgust. CM signs to servant; exit servant back, returns with coat and hat; CM dons and exits back. Exit servant back.

Title: "Seeking Food."

SCENE 3. *Same as Scene 2.* Enter slowly T right. Calls (face business). Raps on table, indicates hunger, sees decanter, makes great show of resistance to temptation, drinks and falls asleep on sofa.

SCENE 4. *Parlor.* Discovered, many guests. Enter CM. Several ladies overly attentive to CM, bores CM much. Exit CM.

SCENE 5. *Same as Scene 3.* Discovered, T asleep. Enter back CM bored. Presently discovers T, calls. Enter two servants. Servants surprised. CM sees letter in T pocket, takes letter and reads.

Title: (Repeat title showing letter in Scene *1*.)

(*Back to Scene 5.*) CM (face and stage business) forms plan for a lark. CM puts money in T pocket in place of letter. Orders servants. Exeunt servants right, carrying T. Exit CM back.

SCENE 6. *City park, second set.* Enter servants left carrying T; place T on bench. Exeunt servants left.

Title: "The Club Man Plans to Take the Tramp's Place."

SCENE 7. *Same as Scene 5.* Enter CM back dressed as tramp. Enter servants right. CM explains, servants try to dissuade but fruitlessly. Exit CM back; servants in despair.

CHAPTER II. The normal or main action of the drama.

SCENE 8. *Outside Village Store.* Discovered, grocer and first and second farmers. Enter CM as tramp. Shows letter to grocer. Grocer surprised, tells farmers, farmers surprised, all welcome CM. Grocer indicates direction, CM exit right.

SCENE 9. *Outside Village Cottage, back yard.* Discovered, GF in chair. Enter from cottage G with newspaper, show of affection, G gives paper and exit into cottage. Enter CM right, inquires of GF, introduces self, GF refuses to accept identity, CM shows letter, GF accepts identity and welcomes CM, GF calls, enter G from cottage, introduction, surprise, welcome, face business of admiration by CM, all exeunt into cottage.

Title: "Unpleasant Duty."

SCENE 10. *Same as Scene 9.* Enter from cottage GF with hoe, and CM. Exeunt right.

SCENE 11. *Field.* Enter GF and CM left. GF hands hoe, to CM and indicates work in field. CM takes off coat and begins awkwardly, GF scolds, CM works harder, exit GF left.

Title: "Pleasant Duty."

SCENE 12. *Same as Scene 11.* Discovered, CM hoeing in field. Business of weariness, lights cigarette, sits on coat. Enter G left. CM hides cigarette quickly, welcomes G. G indicates leaving together, exeunt together left.

SCENE 13. *Village Street.* CM and G pass across together, right to left.

SCENE 14. *Same as Scene 8 with children playing in extreme background.* Discovered, grocer and first and second farmers. Enter CM and G right. Exeunt into store CM and grocer and first farmer. Second farmer proposes marriage to G, indicating his wealth. Refused by G. Exit G into store. Enter from store G, grocer, first farmer and CM carrying packages. Exeunt CM and G right. Enter CM right, pays grocer, exit CM right. Stage business indicating that CM is accepted and well liked.

SCENE 15. *Same as Scene 9.* Discovered, GF in chair. Enter CM and G right, welcome by GF, exit G into cottage, exit CM right, stage business by GF indicating that CM is accepted and well liked.

CHAPTER III. The interfering action of the drama.

SCENE 16. *Same as Scene 6.* Discovered, T asleep. T wakes, remembers letter, finds paper money in pocket instead, is surprised, exit right in glee.

SCENE 17. *Same as Scene 14.* Discovered, grocer, first and second farmers. Enter T right. Recognizes grocer, grocer denies T identity, exit grocer into store. T recognizes first farmer, first farmer denies T identity, guards his watch and exit right. T recognizes second farmer, but second farmer avoids hand and eludes T, making exit into store. T alone on stage, face business of wonder and surprise. Exit T right.

SCENE 18. *Same as Scene 15.* Discovered, GF in chair. Enter T right, recognizes GF, GF denies T identity. T lip language and gesture, "I am me."

Title: "The Tramp Proves His Identity."

(*Back to Scene 18.*) T (stage business) tells of accident while swimming and diving as a boy and shows scar on head, shows birthmark on neck. GF satisfied with identification, calls to cottage, G enters from cottage, introduction, G surprised. GF angry, calls off stage right, CM enters right, shows agitation on seeing T, GF rages, GF orders CM away, G tries to follow, GF interferes, exit CM right, exeunt G, GF, and T into cottage.

SCENE 19. *Interior cottage bedroom, practical door at back opening inward with lock and key, practical window right.* Enter G and GF, GF rages, G cries, GF puts key in door on outside, exit raging and closes door. G tries door to show it locked, sinks crying by bedside.

CHAPTER IV. The resolution of the plot and the conclusion of the drama.

SCENE 20. *Same as Scene 13.* Enter CM right, walking rapidly, hesitates, shows much money, laughs, turns, exit right.

SCENE 21. *Same as Scene 19.* Discovered, G crying by bedside. Enter CM, head only at window, calls, G responds slowly, confusedly, then quickly. CM invites elopement, G consents, gets wrap, exit through window.

SCENE 22. *Same as Scene 20.* Discovered, first and second farmers approaching in extreme background. Enter CM and G right, talk, CM shows and offers money and by accident drops paper from pocket when taking money from pocket, G refuses money, embraces CM, exeunt G and CM left. Farmers reach foreground, converse excitedly. First farmer exit right. Second farmer sees paper, reads, and exit right.

SCENE 23. *Same as Scene 18.* Discovered, GF in chair. Enter first farmer right, tells GF of elopement. GF exit to cottage.

SCENE 24. *Same as Scene 21.* Enter GF by door, looks around room, notices open window, stage business of despair and rage, exit through door.

SCENE 25. *Same as Scene 23.* Discovered, first farmer. Enter GF from cottage, raging. Enter second farmer with paper, shows paper to GF. GF reads. All exit right, GF raging.

Title: "The Marriage."

SCENE 26. *Same as Scene 5.* Enter CM as tramp and G back. CM rings; enter two servants back; CM orders first servant; exit first servant; CM orders second servant; exit second servant. Stage business of love scene. Enter first servant and woman, stylish, age 40, apparently relative of CM, introduction to G, enter two men well dressed. Enter second servant and minister. CM explains to minister; produces paper, apparently license to wed, and hands to minister; minister reads, indicates readiness, performs marriage ceremony; congratulations by all. In midst of confusion, enter GF raging and first and second farmers. GF tries to seize G; G clings to CM; servants and guests interfere; CM tells GF they are married; G tells GF they are married; minister tells GF they are married; GF in despair and rage, farmers in despair.

Title: "Convinced of Son-In-Law's Wealth, Father Forgives."

(*Back to Scene 26 with minister talking to GF.*) Minister explains to GF that CM owns the house. GF surprised, asks servants, who answer yes; asks men, asks woman, asks CM; all answer yes. Still hesitates, gesture of appeal from G, GF takes G and CM in arms and dances. All joyous. (End of picture.)

SPECIMEN COMEDY

The requirement of a comedy is that there be a laugh at the close, and as many before that as possible. In a comedy which is neither chase nor trick, the plot should show the successive steps of story telling: first, the prologue setting forth the conditions under which the action of the story is to occur; second, the action of the story, which may be in several parts; and last the resolution and conclusion.

TITLE

The Old Maid's Dream

PLOT

Comical spinster falls asleep on park bench; nearby sits man accompanied by large dog. Spinster dreams she is being kissed. Wakes and finds dog licking her face.

SCENARIO

Cast of Characters

Spinster, burlesque in manner and attire
Man, portly and dignified
Dog, large and shaggy preferred
Parlor Maid
Several well dressed young men

Scene Sets

Park with two adjacent seats
Parlor

Synopsis

CHAPTER I. Prologue.

SCENE 1. *Park with two adjacent seats.* Enter spinster right, takes nearest seat. Enter man and dog left, man takes remaining seat, spinster much disgusted. Man falls asleep. Spinster glowers and fusses but sticks to the seat and finally shows drowsiness.

Title: "The Dream."

SCENE 2. *Parlor.* Discovered, spinster reading letter and smiling much. Enter parlor maid, announces caller, exit and return with first young man. Exit parlor maid. Welcome of man by spinster, man begins to kiss spinster. Enter second young man unannounced, surprise and confusion of all; exit first young man hastily in confusion. Business of love-making by second young man and spinster, young man begins to kiss spinster. Enter two more young men unannounced, surprise and confusion. Enter more young men, all give excess attention to spinster, then begin talking among themselves as if quarreling about spinster; meanwhile one young man is aside with spinster and begins kissing excessively.

Title: "The Reality."

SCENE 3. *Same as Scene 1.* Discovered, man on seat asleep and spinster on other seat asleep, dog licking spinster's face. Spinster wakes, horrified, belabors dog with umbrella and then belabors man with umbrella. Exit dog and man, left.

Title: "But It Was a Lovely Dream."

(*Back to Scene 3.*) Stage business of rage by spinster looking off left, then slowly subsides, sits on seat, clasps hands, smiles and looks upward in attitude of blissful reverie. (End of Picture.)

The reviewing editor of a motion-picture manufacturing company probably would read as far as "Dog," and reject the manuscript. Trained animals are almost an impossibility in motion-picture production. It would be necessary to find an actress who possessed such a dog, or an actor who could make up as a spinster and who possessed a dog which would lick its master's face. Aside from this, there is the method of enticing the dog by food or sugar, but this is remote in probability of a successful picture.

SPECIMEN CHASE AND TRICK SCRIP

When trick pictures are written, the author must keep his tricks within the possibilities of the art. In chases, the author's scenes must be influenced by the opportunities of the producer. In the following "scrip"—as the written story of a picture before production is called—the title, plot, and scenario are given, and these should be followed by a set of trick notes by the author explaining for the benefit of the producer how the various trick scenes shall be or may be produced.

TITLE

High Jumping Johnnie

PLOT

Johnnie is an acrobat out of a job. Hungry, he buys a sandwich but has no money to pay. The sandwich man chases him. He runs into an apple cart, upsets it, and the apple man chases. Upsets stand of newsdealer, who joins chase. Upsets baby carriage, nurse joins chase. Collides with policeman, who joins chase. The chase now being on, Johnnie easily vaults a wall, which the others require ladders to climb. In a barn-yard, hay-loft door of barn is 8 feet from ground. Johnnie vaults in easily; others try, but must enter by door; when all are in, Johnnie jumps out of loft door and flees down a country road toward a bridge. Johnnie jumps from bridge into water; pursuers follow; Johnnie jumps back from water onto bridge; pursuers must climb out over the bank. In hot pursuit down country road, Johnnie jumps sheer to the sky and catches a passing airship, making final getaway. (See trick notes; practical airship not required.)

SCENARIO

Cast of Characters

High-Jumping Johnnie, an acrobat, must jump well, swim well, and have experience on the horizontal bar
Double for Johnnie, or dummy substitute
Men, first and second
Aviator, and assistants
Pursuers, including policeman, nurse, men, etc.

Scene Sets

Circus tent entrance or exterior (Studio)
Another circus tent with entrance and sign (Studio)
Cloud canvas on rollers. (See trick notes J and L)
Bedroom (Studio)
Office building entrance, with sign
City street scenes
Country scenes
Bridge and water scene

Property List

SCENE 1. Bed, table, chairs, washstand, mirror, comb, washbowl, water pitcher, towel, dumb-bells, Indian clubs, circus bill.
SCENE 2. Sign, packing box.
SCENE 4. Sign.

SCENE 5. Park seat, sandwich wagon with sandwich material complete, white apron and cap and large fork for sandwich man.

SCENE 6. Apple cart and apples.

SCENE 7. Trestles and boards to be knocked off; newspapers and magazines.

SCENE 8. Baby carriage; dummy baby; stripe uniform for nurse.

SCENE 9. Uniforms for two policemen.

SCENE 10. Trestle for jump from fence; two or three ladders, say six-foot, eight-foot and ten-foot, one each.

SCENE 14. Dummy for Johnnie if double is not available; duplicate costume for double if double is available.

SCENE 17. Airship. (See trick notes.)

SCENE 18. Horizontal bar.

Synopsis

CHAPTER I. Prologue.

SCENE 1. *Bedroom, poorly furnished; dumb-bells and Indian clubs on floor; circus bill announcing "High-Jumping Johnnie" on wall.* Discovered, Johnnie washing face. Takes short turn with clubs or dumb-bells, dresses for street, stage business toward circus bill on wall, looks at watch, exit through door.

Title: "Loses His Job."

SCENE 2. *Exterior of circus tent entrance. Sign on tent, "Closed by Sheriff."* Discovered, first man sitting on packing box near tent wall, head in hands. Enter Johnnie, sees sign, consternation at sign, taps man on shoulder, asks about sign, man shakes head. Johnnie indicates pocket and stage business of asking whether anybody gets any pay; man shakes head. Man assumes disconsolate pose again. Exit Johnnie, doleful.

SCENE 3. *Another circus tent entrance.* Enter Johnnie at one side, exit into tent; enter from tent Johnnie and second man; Johnnie is asking for employment, stage business of showing that he is an acrobat; man shakes head always indicating no work for Johnnie. Exit man into tent. Exit Johnnie one side after stage business of disappointment and hunger.

SCENE 4. *Office building entrance. Sign at door reads, "Theater Agency. Vaudeville Acts Wanted."* Enter Johnnie one side, sees sign, business of joy, exit into office building entrance; business of passers-by; enter Johnnie from office building entrance, sorrowfully. No work. Exit one side after stage business of hunger.

CHAPTER II. The Chase, in the city.

SCENE 5. *Edge of park; park seat left; red-hot sandwich man and cart at curb at right; camera set to panoram from seat to sandwich cart.* Enter Johnnie, left, disconsolate. Hunger, despondency. Looks off stage right, becomes thoughtful, rises and walks toward right. (*Panoram camera to follow actor.*) Stops at sandwich cart, talks with man, orders sandwich; man makes sandwich and hands to Johnnie; Johnnie takes bite; man asks for pay; Johnnie explains; man angry; Johnnie continues explaining; man threatens; Johnnie runs with sandwich; man follows with apron, cap, and fork; exit around convenient street corner.

SCENE 6. *City street.* Discovered, apple man and cart. Enter Johnnie running, collides with cart and falls, but holds on to sandwich; scatters apples in street. Johnnie recovers feet, picks up an apple, puts apple in one pocket and sandwich in another and runs off stage. Enter sandwich man; exit sandwich man and apple man pursuing Johnnie.

SCENE 7. *City street corner. News stand and attendant.* Enter Johnnie running, collides with news display, upsetting it but keeps on running. Enter pursuers, business with newsdealer, who joins chase. Exeunt, running.

SCENE 8. *Residence street scene.* Enter nurse with baby in carriage. Enter Johnnie running, collides with carriage, overturns carriage but keeps on running. Enter pursuers. Exeunt pursuers running, including nurse, baby, and carriage.

SCENE 9. *Street corner in residence district.* Enter left up one street two policemen. Enter right up other street Johnnie running. At corner, Johnnie collides with policemen. Exit Johnnie, running, left. Enter right pursuers running after Johnnie, talk with policemen, exeunt all running left.

SCENE 10. *City or suburban scene with wall 8 feet high.* Enter Johnnie, makes running jump sheer to top of wall (Trick Note A) and down on opposite side. Enter pursuers. Run to wall, attempt to climb but all fail. Exeunt two or three and enter again with short ladders, all scale wall and vanish on other side.

CHAPTER III. The Chase, in the country.

SCENE 11. *Country with fence and gate.* Discovered, Johnnie in background, running toward camera, clears fence by leaping from earth to top of fence and again to earth (Trick Note B), runs toward camera, and exit. Enter pursuers who at first try to climb fence but discover gate and open it, passing through gate and toward camera and exeunt in pursuit.

SCENE 12. *A steep earth bank 5 feet high.* (Note C.) Enter Johnnie on top of bank, leaps to bottom; enter pursuers, following and coming down bank; exit Johnnie on lower level; exeunt pursuers following.

SCENE 13. *Similar to Scene 11, adjacent part of same bank.* Enter Johnnie on lower level, leaps to higher level (Trick Note D) and keeps on running. Exit Johnnie. Enter pursuers, lose much time in climbing to higher level. Exeunt.

SCENE 14. *A barnyard and barn, with doors at ground level and loft door about 8 feet above ground level.* Enter Johnnie and leaps into open loft door (Trick Note E). Enter pursuers and try to make loft door but fail. Johnnie takes sandwich from pocket and takes a bite, sandwich man rages. All pursuers take lower door to barn. When all are in, Johnnie jumps from loft door and exit; pursuers appear in loft door, some falling through loft door to earth and others returning by lower door. Exeunt. (Note F.)

SCENE 15. *A country road with bridge in middle distance.* Enter from foreground Johnnie and pursuers very close behind, all running toward bridge.

SCENE 16. *Near the bridge of Scene 14. Bridge is at left; the foreground is water under and near the bridge; in the middle ground is the distant bank of the river.* Enter Johnnie, left, on bridge, closely pursued. Johnnie jumps from bridge into water, pursuers all follow. When all are in the water, Johnnie jumps sheer from the water to the bridge again (Trick Note G) and runs off bridge left; pursuers lose much time climbing out of water upon bank in middle ground and exeunt after Johnnie.

CHAPTER IV. Conclusion.

Title: "The Airship."

SCENE 17. *Open country, with airship or aëroplane on ground.* Enter aviator and assistants, right; walk to airship; examine all parts carefully; aviator takes driver's seat, assistants start propellers and exeunt; airship starts and passes off stage, right, rising. (Trick Note H.)

SCENE 18. *Country road.* Enter Johnnie and pursuers, from background, running toward camera. All notice airship (off stage) and stop running, looking up. Johnnie makes sheer leap to sky, from extreme foreground, off stage through top of picture. (Trick Note I.) Pursuers run forward and off stage, always looking upward, showing amazement and chagrin after Johnnie's leap.

Title: "Safety at Last."

SCENE 19. *Airship in flight in foreground, clouds in background.* (Note J.) Johnnie enters through bottom of picture, extreme foreground, seizes airship and climbs aboard. (Trick Note K.)

SCENE 20. (Note L.) *Near view of airship.* Discovered, Johnnie, who nearly fills the screen. Takes sandwich from pocket and apple from another and eats, with stage business downward as if to pursuers on earth below. (Note M.)

SCENE 21. *Country roadside.* Discovered, all pursuers in state of collapse, one or two showing rage and gesticulating toward sky toward Johnnie in airship. (End of picture.)

The average picture-play editor would read that "scrip" only so far as the first time he saw the word "airship," were it not that the mention of airship is coupled with the memorandum, "See Trick Note."

TRICK NOTES

Trick Note A. *The leap to top of wall and the entrance may be made in one action with reversing camera. Johnnie takes position on top of wall, back to camera; mark chalk line around both feet; start reversing camera; Johnnie stoops, puts hands on top of wall, leaps backward to earth, easing leap with hands on wall; then runs backward off stage at entrance point. When reversed in the print, this enters Johnnie and carries him to the top of the wall in a flying leap. To complete the scene, Johnnie takes same position on top of wall, feet in chalk lines, and assumes as nearly as possible same attitude; start direct camera; signal pursuers on; pursuers enter and Johnnie leaps forward from camera out of sight. A platform beyond the wall may shorten the leap, which should not have the aid of hands. The two actions, reverse and then direct, complete the scene.*

The leap to top of wall and the entrance may be made in two actions. First action: Johnnie takes position on top of wall, back to camera; mark chalk line both feet; start reversing camera; Johnnie stoops, puts hands on top of wall and leaps backward to earth, easing leap with hands on wall; mark carefully around feet and around hands if hands touch earth. Second action: Start direct camera without actors; Johnnie enters, runs to wall, and takes exact position with feet as marked in jump from wall, assuming as nearly as possible the same attitude *as when landing from the wall. Third action: The scene from top of wall, with direct camera, as before. The three actions, direct, then reverse, then direct, complete the scene.*

The leap before the reversing camera should be backward, not face toward the camera, and the effect of the hands upon the wall is that at the end of the rise they help Johnnie to gain the top with his feet and acquire a momentary equilibrium there. The scene in two actions is preferred if Johnnie is competent to run backward realistically. If the three-action method is adopted, the change from the first entrance to the reversing action may be made either at the point of leaving the ground for the leap, or a few steps prior to rising.

Trick Note B. *Same method as for Trick Note A. Mark with chalk the position of the feet upon the top of the fence. With Johnnie "jumped" into the picture, running almost directly toward the camera and on the distant side of the fence, the awkwardness of running backward will be obscured and less running backward will be required, so that the two-action method should be thoroughly feasible. In the second action, enter the pursuers before Johnnie leaves the fence jumping down.*

Note C. *One side of a railway cut ought to serve for this scene set. A water-washed gulley or river bluff with beach at bottom is suitable.*

Trick Note D. *Same method as for Trick Note A. The backward leap for safety's sake, should be squarely backward and not diagonally over the bank. Use hands as before. Mark position of feet as before. Two-action method preferred, and Johnnie may be "jumped" into the picture if desired.*

Trick Note E. *Same method as for Trick Note A. As it is desirable that the pursuers shall enter as quickly after Johnnie, the last action of the scene may start with Johnnie in crouching position in loft door with back to camera, the pursuers coming on while he rises and turns to face out of the door.*

Note F. *Scene 14 may be staged in a city house if preferred, selecting a house with high first floor, the windows being about 8 feet from the ground. Johnnie jumps into an open window, pursuers rage under window, then enter house up steps and through front door, then Johnnie jumps from window and runs.*

Trick Note G. *Scene 16 may be made according to any one of three methods, which may be named the double method, the dummy method, and the repeater method. The first is preferred if an actor for Johnnie's double is available.*

The "double" method is so named because it uses two actors who are "doubles," looking so much alike or made up so much alike that the audience does not distinguish them one from the other. As the substitute for Johnnie appears for but a brief period and is in active motion all the time, the resemblance need not be exceedingly accurate. In producing Scene 16 direct and reversing cameras are used. First action: Johnnie's double enters left, on bridge, direct camera running, and jumps from bridge into water, followed even before diving by the leaders of the pursuers, who plunge after him. Second action: When all pursuers are in the water, start reversing camera. Pursuers make much splashing but make no progress in swimming forward, but anyone skilled in swimming backward may do so. Enter the real Johnnie walking or running backward, entering left on bridge and walking backward to the point of diving, diving backward if he has sufficient skill in diving, a straight backward jump, striking the water feet first being preferred. Third action: Start direct camera. Pursuers may *swim forward now and climb out upon bank opposite camera, thence running across bridge and exeunt left. The actions are used in the scene in the order in which they are taken. In the last action Johnnie must not be seen, even though the camera must be stopped to get him out of the picture.*

The "dummy" method requires a weighted dummy resembling Johnnie. In the first action, the real Johnnie runs on left and crouches upon the edge of the bridge, simulating a leap as nearly as possible, but does not go into the water. The camera is stopped, a dummy is substituted, held by a string running off stage; start the camera, release dummy by the string and order pursuers on. The dummy is weighted to sink when it strikes the water. Second and third actions as before. Poorest of the three methods.

The "repeater" method requires Johnnie to dive twice and uses a dummy as well, but the dummy merely makes a splash and does not appear in the picture, so a weighted bag is sufficient. The first action is in two parts. Johnnie runs on left and dives from bridge; stop camera; Johnnie comes from water; dummy is fixed to bridge to be released to make splash by pull of string running off stage. Start direct camera, release dummy weight for splash, order pursuers on as water splashes. Second and third actions as before, the second action being all the better because Johnnie's clothes show wet.

Trick Note H. *Scene made in two actions, the second action being with reversing camera. Build a dummy aëroplane after the Wright biplane model, an easy type to copy in dummy. Arrange it to slide backward to earth on a pair or more of inclined wires. Must have practical propellers turning very easily by slight breeze. Make second action of scene before making first action.*

Second action: With reversing camera. Enter airship with aviator in driver's seat, sliding backward down inclined wires, propellers turning. Airship stops on ground, but propellers keep on turning; aviator takes tableau attitude to be assumed again in first action.

First action: With direct camera. Discovered, the aëroplane just as it was in tableau of second action, but without aviator and with propellers stopped. Propellers may be tied to frame with a light string easily broken. A sufficient breeze should be blowing to turn the propellers continuously after they have started. Enter aviator and assistants, or they may be "discovered" or "jumped in." Inspect airship thoroughly. Aviator takes seat; assistants start propellers by turning them forcibly which breaks string and breeze then keeps them turning. Exeunt all assistants left. Aviator in driver's seat assumes the tableau pose of the second action, made at the close of the second action in front of the reversing camera and, therefore, appearing at the beginning of the second action of the scene in reproduction.

In lieu of the dummy airship and the staged action, a bona fide airship or aëroplane making a bona fide start or a view of an airship in flight would serve the purposes of Scene 17. Stock actors need not appear in the scene. One direct action scene of a bona fide airship under any condition of motion would be all that the scene requires, the trick feature of the start of the dummy being entirely obviated.

The entire series of scenes involving the airship or aëroplane may be made with a free balloon instead, if the properties are more easily available to the producer. Scene 17 is then a bona fide scene of any balloon ascension. In Scene 18, Johnnie leaps to catch a dangling rope. Scene 19, the basket of the balloon is seen *and Johnnie enters by climbing the rope through the bottom of the picture. Scene 20 is staged in the balloon basket.*

Trick Note I. *In front of the camera and as high as Johnnie can jump and catch is a fixed horizontal bar such as acrobats use. The camera is set to take the ground below the bar as the foreground line of the picture and to clear a foot or more between the bar and the upper line of the picture, the bar being above the picture. With a bar 7 to 8 feet from the ground and with a 3-inch lens in the camera, the distance from camera to bar would be about 24 feet. The distance between standards supporting the bar must be more than 8 feet that the standards may be out of the picture. The shadow if any must fall toward the camera, that it may not show in the picture. When Johnnie leaps and catches the bar he pulls himself out of the picture as rapidly as possible, and at that time all eyes have been fixed above the horizontal bar, as though the airship were just there, and as though Johnnie has jumped and caught the airship. If he can get out of the picture quickly enough, it will seem that he has jumped higher than the picture to catch the airship.*

Trick Note J. *The airship (dummy or bona fide) is rigidly supported by invisible wires or by trestles at its ends, in the latter case the camera being set close and the trestles being off the sides of the picture. Flight is simulated by painting clouds on a canvas band and mounting the canvas on rollers and moving the clouds past the ship as a moving background. A slight panoram movement and vertical rocking movement of the camera simulates the tipping and swerving of the airship in flight.*

Trick Note K. *Johnnie enters by jumping upward and catching the airship as an acrobat catches a horizontal bar, then climbs aboard.*

Note L. *A near view of the motionless airship. If the cloud curtain on rollers is used, it may be shown as a background, Scenes 19 and 20 being combined. If roller cloud curtain be not available, the view may be so taken that no motion is needed, Johnnie and the near parts of the airship filling the screen, with possibly the aviator also visible. Use the rocking or panoram of camera to simulate the airship's movement.*

Note M. *If bona fide airship is available, no trick flights are required, all pictures being made with the airship at rest except the bona fide start, or a short bona fide view of the airship in flight. If stock negative of an airship in flight is available, it may be used for Scene 17 and the dummy for Scenes 19 and 20 may be of a design in imitation of the airship of Scene 17.*

SPECIMEN TRAVEL SCRIP

As a task for an author, the writing of a scrip for a travel picture is not a long nor a difficult task. It is at most a guidance for the producer. In many cases the author's scrip may be dispensed with altogether, the producer going into the field equipped with the camera only and making photographs of whatever opportunity may offer in the hope of piecing them together to form an acceptable series. The following scrip is a specimen which might be given to a producer as his instruction, with liberty to omit any unduly difficult scene and to add whatever scenes may be offered by chance.

THE MARRIAGE OF NAPOLEON TO MARIE LOUISE
Scene from the Vitagraph Life Portrayal of "Napoleon, the Man of Destiny"
Courtesy of the *Vitagraph Company of America*

SCENE FROM PHOTOPLAY, "BACK TO THE PRIMITIVE"
Courtesy of *Selig Polyscope Co., Inc., Chicago*

TITLE

A Trip Across Lake Michigan

PLOT

A trip beginning in Chicago and ending in South Haven, Michigan, via steamer "Westland," showing something of fruit traffic.

SCENARIO

Cast of Characters

None

Scene Sets

None Special

Synopsis

Title: "Chicago River."

SCENE 1. Panorama from one of the bridges, showing large passenger steamers at dock, showing particularly the *Westland*, on which the trip is to be made.

SCENE 2. Turning of a bridge and passing through of a large freight boat.

SCENE 3. Leaving of the little passenger boat on its frequent trips down the drainage canal.

Title: "Away for Vacation Days."

SCENE 4. Ticket window, people buying tickets.

SCENE 5. Gangplank of steamer, people going aboard.

Title: "Leaving the River."

SCENE 6. Travel scene from bow of boat, showing opening of Rush Street bridge to let boat through. Better make this with trick handle, half speed. Show also points of interest on banks of river and lighthouse on pier at mouth of river.

Title: "Chicago Water Front."

SCENE 7. Panorama of Chicago water front. Make this from the outer breakwater, two or three camera stands if necessary.

Title: "Out of Sight of Land."

SCENE 8. Panorama of waves, showing details of boat structure, sweeping the horizon rapidly from stern of boat to stem without showing land.

Title: "South Haven, Michigan, Breakwater."

SCENE 9. View from bow of steamer as vessel approaches the mouth of the river. Trick handle probably.

Title: "South Haven."

SCENE 10. Panorama of South Haven water front. Make from lighthouse at end of pier.

Title: "Oh! There you are!"

SCENE 11. Passengers disembarking from boat. Greetings by friends. May require some posing and stock actors.

Title: "Off for a Day on the Farm."

SCENE 12. 'Bus, loaded, driving down village street, passengers waving to camera man.

Title: "Peaches."

SCENE 13. Peach orchards, picking peaches, packing in baskets, hauling to town, loading on steamer for Chicago market. Grapes, plums, anything that can be had of the fruit industry. Several scenes.

Title: "South Haven Amusements."

SCENE 14. Dance pavilion, roller coaster, the little launch on the river loaded with passengers. Several scenes. (End of picture.)

The picture-show patrons like the dramas and comedies and as a rule find the travels tiresome. They demand the dramas and make caustic remarks about the dry travels. The theater managers get this sentiment from their patrons and, in turn, take it to the film exchanges, refusing travels sometimes when offered for exhibition. The film exchanges, in turn, carry this sentiment to the manufacturers. The result is a strange dodge on the part of the film manufacturers, producing what might be called a *travel and drama* or *travel and comedy*. It is produced by combining something of a dramatic or comic nature with the scenery which is to form the subject for the travel picture.

SPECIMEN TRAVEL AND COMEDY SCRIP

The following is a specimen scrip for such a film picture:

TITLE

Sammy at Niagara Falls

PLOT

A scenic review of Niagara Falls. Sammy takes a train and arrives at the Falls. In recording Sammy's adventures at the Falls such scene sets are chosen as to *do* the falls completely

SCENARIO

Cast of Characters

Sammy, ordinary dress except a comical cap
Office help
Visitors at Falls for passers-by business

Scene Sets

Office scene
Bedroom, poorly furnished
A railway station
Another railway station, with sign, "Niagara Falls"
Natural scenery at Niagara Falls, New York

Synopsis

Title: "Sammy is Off for a Vacation."

SCENE 1. *Office, with Bookkeeper and Typewriter Operator.* Discovered, Sammy, bookkeeper, stenographer, other help. Sammy in great glee, talks to all, serially, makes more confusion than headway with his work, bookkeeper hands him pay envelope, Sammy tears open and takes out money, waves money in glee, gets hat, exit, all stopping work and waving adieu.

Title: "Where Shall I Spend My Vacation?"

SCENE 2. *Bedroom.* Enter Sammy, in glee, carrying newspaper. Takes off hat and coat, sits, feet up, reads paper with frowns, suddenly great glee, holds up paper.

Title: "Newspaper. Page, showing advertisement, railway to Niagara Falls and return $4.60, tickets good one week."

(*Back to Scene 2.*) Sammy throws down paper, takes hat and coat, takes money from pocket and replaces it, exit.

SCENE 3. *Railway station platform.* Enter Sammy, paces platform impatiently; enter supes and passers-by. Enter train, Sammy gets on board, exit train.

SCENE 4. *Railway station platform, with station sign "Niagara Falls."* Enter train. Enter passengers leaving train, Sammy last, exit Sammy one side.

SCENE 5. Panorama of the Falls, from any convenient elevation, such as balcony at Windsor Hotel, Canadian side.

SCENE 6. Prospect Point. Shows American Falls and protecting railing at Prospect Point. After panorama to show scene, when scene is nearly out, enter Sammy with fish pole and begins to bait hook.

SCENE 7. The stone bridge. While panoraming the bridge, Sammy nearly gets run over by a rig while walking around in the roadway with a tin cup looking for water, stage business of thirst.

SCENE 8. Terrapin Island. View from Goat Island, showing bridge to Terrapin Island, panoraming for view. As view nears end, Sammy comes out half way across Terrapin Bridge with a string on his tin cup, lowers the cup into the water, hauls it up and gets a much satisfying drink.

SCENE 9. Maid of the Mist. Show boat at dock, and passengers including Sammy passing aboard, Falls in background. .

SCENE 10. Camera on board the Maid of the Mist. Near view of the Falls. Sammy appears at rail in near foreground of camera and is deathly seasick.

SCENE 11. Cave of the Winds. Panoram for view, then pick up Sammy and panoram him half way across the bridges between Goat Island and the Cave of the Winds. He becomes afraid and turns back. Again attempts it, but again turns back, this time finally. Camera keeps him in field continuously. (End of Picture.)

Such a combination enables the film manufacturer to render his travel pictures more acceptable to that class of patron disliking the travel in its pure form. The exhibitor also has opportunity to advertise the picture in his theater front announcement either as "A Roaring Comic" or as "A Beautiful and Wonderful Nature Picture."

SPECIMEN INDUSTRIAL SCRIP

To depict an industry completely sometimes requires pictures taken in various parts of the world. "The Rubber Industry" should begin with views of the tropical rubber trees, curing the sap for shipment and loading on vessels. Then the scene shifts to the northern factory, the processes of bringing the rubber into commercial shape and the manufacture of some well known article wholly or largely composed of rubber. The picture may close with a scene showing manufactured article in use. The scenes taken inside the factory doubtless would require artificial lighting.

An industrial film well done sometimes involves scenes of great difficulty, and even trick pictures. The following specimen scrip calls for the "stop" picture.

TITLE

Raising Watermelons

PLOT

Preparing the ground and planting. Then a growing vine by stop picture. Picking, loading, hauling, loading cars, freight train in transit to city, melons on sale in city store front.

SCENARIO

Title: "Preparing the Ground."

Scene 1. (Select a scene with picturesque background, showing gate from field to highway. Take camera stand to panoram field, gate and highway, including background objects. Build permanent camera stand, that the identical position of camera may be taken from time to time.) Plowing and fertilizing in the fall.

Scene 2. From same viewpoint, a snowstorm scene.

Scene 3. From same viewpoint, a sleigh passing on the highway.

Title: "In the Spring, the Work Begins Again."

Scene 4. From same viewpoint, spring plowing.

Scene 5. Forming the hills for planting.

Scene 6. Planting the seed.

Title: "The Growing Plant."

Scene 7. Stop picture, studio. The hand planting the seed, the breaking of the plant through surface of earth, growing hourly to blossom.

Scene 8. Stop picture of field.

Scene 9. Stop picture of near view of melon.

Title: "Selecting the Ripe Fruit."

Scene 10. View of field with man working, testing melons for ripeness. As he comes near the camera, his tests are clearly seen, and the cutting of the stem and turning up of the white side is shown.

Title: "On the Way to Market."

SCENE 11. Wagon in field, loading the selected melons.

SCENE 12. Panoram loaded wagon through gate and along highway.

SCENE 13. Near shipping point, many wagons, all loaded.

SCENE 14. Loading the melons into railway cars, showing method of handling.

SCENE 15. The melon farmer gets the money at the car door from the shipper.

SCENE 16. From the caboose of a railway freight train, showing train ahead and scenery passing by, running through rural district.

SCENE 17. Same, entering large city.

SCENE 18. City store front, melons on sale. Lady enters and buys. Delivery boy puts purchased melon in basket and exit carrying. (End of Picture.)

Who is the Author. Usually, it is the producer. Surely no author is better qualified to write within the limitations of the motion-picture art than the producer. Surely no producer is better able to interpret a story than the author. In industrials, the producer may look over the situation in the capacity of author and write the scrip in memorandum form as his field notes for working with the camera. With the notes in hand, he takes the camera man and equipment and makes the various scenes which his notes show possible or desirable. In travels, comedy, or dramatic accompaniment, the field should be looked over to learn its possibilities, and no one is better qualified than an experienced producer. In current events, an experienced producer is the best judge of advantageous viewpoints. In chases, the central idea, the joke of the picture, may be sufficient information to pass from the author to the producer, the producer providing scenes to embody the thought in a picture within the limitations of the art and his immediate environment. It is in comedies and dramas that the author as such may be entirely remote from the producer. Scrips for comedy and drama may be written as short stories are written, and may be submitted to film manufacturers as short stories are submitted to magazine publishers.

THE PRODUCER

The producer is in charge of the studio, of the scene painters, of the sign writers, of the stage carpenters, of the property man, of the actors, and is nominally in charge of the camera men.

When the producer undertakes a picture, the scrip is made as complete as he desires by adding details of scenes, notes of probable location of outdoor scenes, names of actors suitable for the parts or notes on actors required to be found for the parts, as well as notes on other pictures being produced or to be produced contemporaneously with the scrip being studied. Studio stage sets and scenery required are noted and a property list is made. The titles also are noted, for title making is a part of the work quite distinct from scene making.

The producer keeps all his departments running as smoothly as possible, the motion scenes for a drama being produced this week while titles are being made for another drama for which the motion scenes were produced last week, and the stage carpenters and scene painters are at work upon studio settings and properties for still another drama for which the motion scenes will be produced in the weeks following.

The order of producing drama is: (*1*) Painting the scenery for the studio sets, for none but the simplest scene sets are used repeatedly. (*2*) Getting the properties and costumes. (*3*) Getting the actors and rehearsing and photographing the motion scenes. (*4*) Producing the motion scenes before the camera. (*5*) Inspecting the proofs of the motion scenes, retaking unsatisfactory scenes and making additional scenes which may seem desirable—sometimes, alas, only for "padding"—after the author's scenes have been reviewed. (*6*) Rewriting the scrip if necessary to fit the drama as embodied in the motion scenes. (*7*) Writing the titles finally and in detail. (*8*) Making the titles. (*9*) Adjusting lengths of titles and scenes to make the desired total picture length.

Studio Scenes. The scenery used for setting the stage differs from the scenery of the dramatic stage by the absence of color. Plain black and white and neutral tints are most desirable, for color is objectionable in that it may be misleading in tone values when photographed. The scenery required is only sufficient to fill the field of the camera. Usually when staging an interior, but two walls of a room are shown. In such a case, the third wall is not needed in the scene set, nor are flies needed for the ceiling. Wall scenery may be made in sections or panels, Fig. 2, and the sections may be set together as desired, making possible the use of the same painted work for several scene sets sufficiently different from each other. If a spectator should recognize any scene as being familiar because

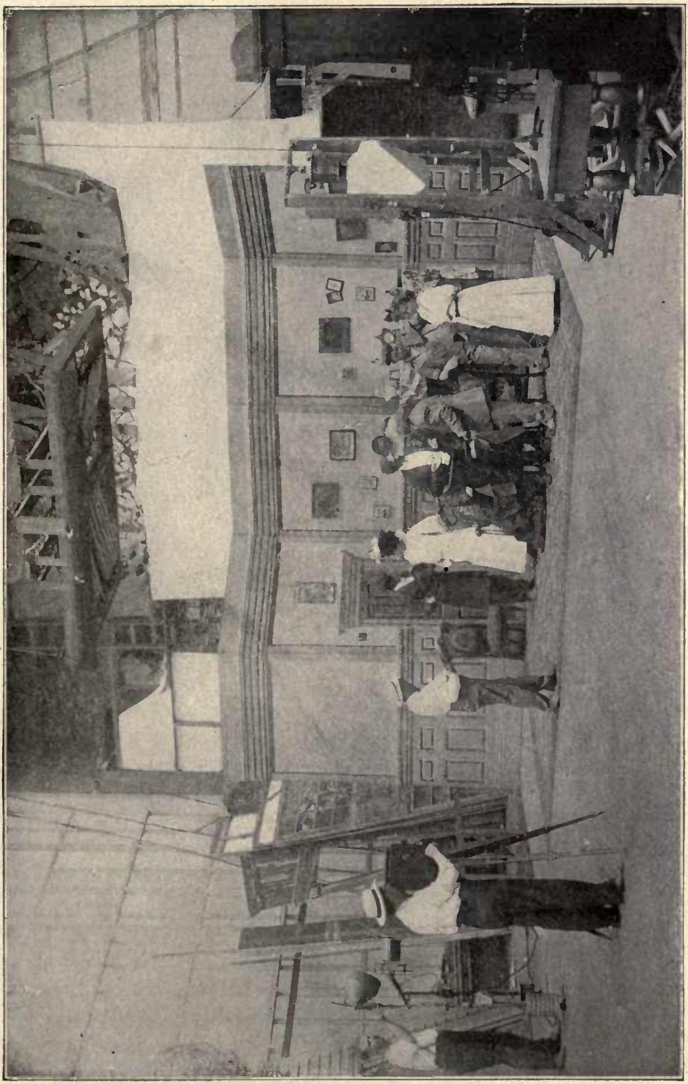


Fig. 2. View of Indoor Studio, Showing Stage Setting for Indoor Scene

of prior appearance in other dramas, the first thought would be that the film then being viewed is an old one. To avoid this, striking scenes and highly special scenes, Fig. 3, are used but once. Only the more ordinary and characterless scenery may be used repeatedly. In Fig. 2, which is a good example of scenery for repeated use, five "flats," each so small that they resemble the "wings" of a dramatic stage setting and each only sufficient in height to cover the film window in the image in the camera, are shown combined for a scene

Fig. 3. View of Indoor Studio, with Stage Setting for Outdoor Scene

set. When rearranged with the door at right or at middle back, new and sufficiently different sets are produced for use in another drama, while with the addition of a flat having a window, still further combinations may be made to use the scenery to its limit before repainting.

A set of scenery flats so designed as to be papered with wall paper may be changed beyond recognition in a few minutes and at a very small expense merely by giving them a new dress of figured paper. For wall paper, the flats should have a width proper to take exactly two or more full width strips of wall paper, and the paper should be applied so that the figures will match at the edges when the flats are set together. Otherwise, the effect is ludicrous.

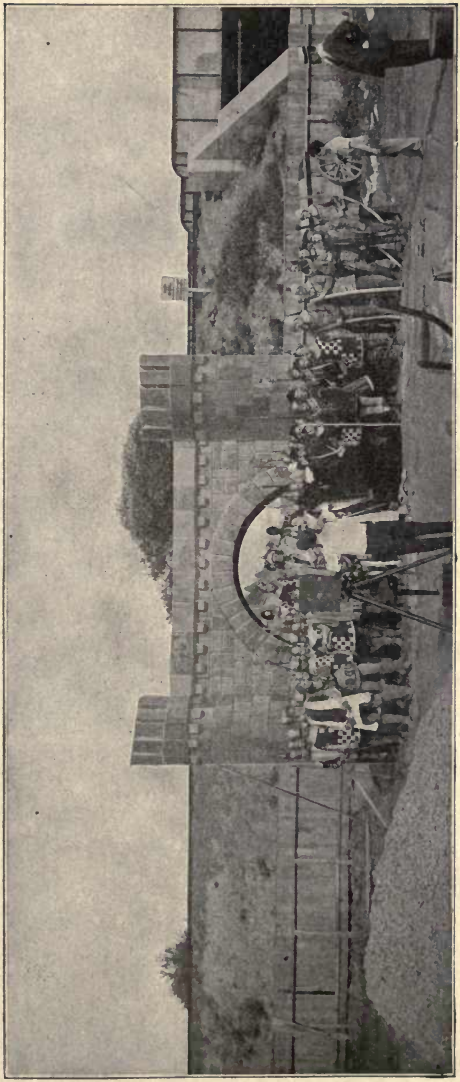


Fig. 4. View of Outdoor Studio, with Stage Setting for Outdoor Scene

In addition to painted scenery for the studio, which may represent either an interior or an exterior scene, painted scenery sometimes is used for outdoor staging. Fig. 4 shows a scene set from a production of "Richard III." made by the Vitagraph Company. The camera stands in the foreground of the illustration, facing the scene set. The field of the image in the camera does not extend to the right and left beyond the painted scenery representing the stone wall, hence in the motion picture there is given the effect of an indefinite stone wall having the arched entrance. Behind the arch is

Fig. 5. Natural Scene Setting, Outside of Cottage

a flat scene with houses and clear sky. This is a painted scene also, placed against the tight board fence which runs across the view at the foot of the railway embankment. Beyond the railway embankment are trees, the tops of which appear above the painted stone wall. In Fig. 2 and Fig. 3, the image in the camera does not extend above the top of the painted scenery; in Fig. 4 the camera includes the top of the wall and a strip of the sky above, an effect which in the studio would require a strip of sky scenery above and behind the wall. The setting of Fig. 4 is properly called a *studio set,* even though not staged inside a building. Fig. 5 shows a natural scene set.

Studio Lighting. *Artificial.* Artificial lighting for studio scenes is most economically done with mercury-vapor lamps. These lamps are made of long glass tubes containing mercury. When glowing, they give a green light, rather disagreeable to the eye at first, but very powerful in acting upon the sensitive photographic film. The light must be sufficient to impress the image upon the sensitive film in the short time allotted by the camera for each of the little pictures. This is a minimum requirement of fifty standard mercury-vapor lamps for a stage set measuring 14 feet wide, for satisfactory results

Fig. 6. Indoor Studio Setting for Outdoor Scene, Showing Lamp Arrangement for Artificial Lighting

in the finished pictures. Studio lamp plants vary from fifty to one hundred and fifty lamps, and vary in cost from $2,500 to $10,000.

As used in motion-picture studios, the mercury-vapor lamps are mounted in groups, usually six or more lamps per group, some of the lamps being hung from the ceiling of the studio for top lights and some being mounted in standing frames for side lights. The lighting arrangement will be clear from a study of Fig. 6. The studio is entirely without light other than the artificial light of the mercury-vapor lamps, which are arranged upon the ceiling and upon both sides of the scene set. In a studio of this kind, it is possible to confine all scenes to the standard stage dimensions of the studio, the lamps being properly arranged and sufficient in number to light that standard stage area properly. Working with a studio of the type illustrated in Fig. 6 makes the producer entirely independent of the weather conditions for his indoor scenes. In Figs. 2 and 3, large windows are placed in the wall of the studio at the left, making possible photography by daylight when the weather is favorable, the daylight being supplemented as desired by the artificial light. In Fig. 2, a bank of mercury-vapor lamps is suspended from the ceiling, and the side lights also are in position. In Fig. 3, a battery

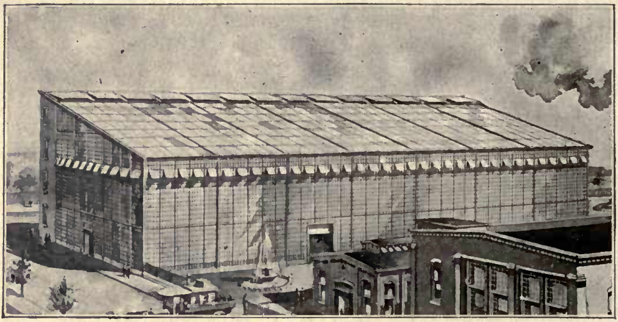


Fig. 7. Lubin Factory, Showing the Glass-Roof Studio

of top and side lights are glowing, although the daylight window is visible at the left in the view.

Daylight. There is a quality in the best daylight picture which is lacking in the best picture made by artificial light. The artificial lighting as used commercially is sufficient to impress the image upon the photographic film, but it does not reproduce in all fidelity the strength and diffusion of daylight, nor the uniformity in intensity and direction throughout the whole scene which is obtained from daylight. Lighting a large stage artificially also involves a large expense.

The daylight studio is of three types—the glass house, the turntable, and the yard. The *glass house type* of studio is shown in external view in Fig. 7. That an auxiliary lighting plant is desirable is evidenced by the details of Figs. 2 and 3.

A studio of the *turntable type* is shown in Fig. 8. The movable platform is turned to get the sunlight in the right direction. Pictures may be made with this platform from early morning until sunset, and the producer may have his light from the desired direction at all times. The exposure to rain and wind are the objectionable features of a studio of this type. It seems hardly natural for the draperies inside a house to be in motion, even in a motion picture. Unless an inside studio also is available, the producer is dependent upon the weather in more ways than sunlight alone.

The *yard studio* is a matter of setting up the scenery in a fenced enclosure, as in Fig. 4. Where the indoor studio is limited in size,

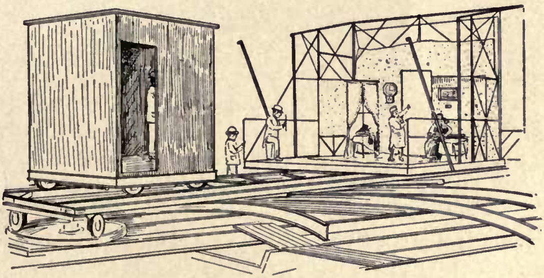


Fig. 8. The Vitagraph Roof Studio, Showing Turntable Construction

the method of Fig. 4 may be adopted for scene sets which cannot be staged in the restricted space. One adjunct usually forming a part of an established yard studio is the tank. The possibility of staging a scene with even a limited amount of water adds much to the producer's possibilities.

Pictures Without Studios. A prominent film manufacturing company operated for years without a studio and without painted scene sets, releasing a reel each week. On several occasions, film manufacturing companies, whose studios and factories are located in the northern latitudes, have sent producing companies to the tropics in the winter, where many complete dramas have been produced before the camera without studio and without artificial scenery.

The beauty and attractiveness of a motion picture is enhanced by avoiding painted scenery and its artificial appearance whenever possible. No painted scenery can equal the detail and accuracy of the physical objects. Fig. 3 would be more pleasing had the camera and actors been carried to Spain for a natural scene setting adapted to the requirements of the story.

It is the custom to stage indoor scenes in the studio with painted scenery; to stage street scenes outdoors in the streets, using the natural street scenes; and to stage rural scenes in the country. A studio set for a street scene may be made thoroughly acceptable by care in preparation of the scenery and by avoiding vegetation in the scenery. In a street scene of long duration, the studio setting is a decided advantage, since the passers-by do not have to be contended with.

The selection of natural settings is a feature of his work by which one producer easily may excel another in the quality of his product. The motion-picture camera has a "narrow angle" eye, permitting the use of a small scenic setting without including the whole country-side as a part of the view. On the contrary, by a change of lenses in the camera, just as much of the whole view as is desired may be included, panoraming the camera if necessary to include still more. The adaptability of the setting to the story is the principal point to be borne in mind when selecting natural scene settings. Pictorial merit in the scene itself is of secondary importance, but still is a matter of much importance when the best of motion pictures are desired.

In outdoor settings, whether wholly natural or wholly or partly staged with painted scenery, constant care must be taken to avoid incongruous features of the background from appearing in the picture. A scene which by the story of the drama is set in the fastnesses of a mountain range, far from any civilization, when staged in a ravine near the studio should not show a house gable in the remote distance. The scene set in Fig. 4, as viewed by the fixed camera which made the illustration, shows tree tops above the stone wall, yet the tree trunks do not appear through the arch of the wall. This would be an error if it were to appear so in the finished motion picture. The motion camera in the illustration is nearer to the scenic stone wall, thus by its different perspective and narrower lens angle placing the top of the wall higher in the sky and above the tree tops, so that the tree tops are not seen in the motion picture.

Properties and Costumes. The articles or "stage properties" used by the actors, include furniture and all kinds and classes of house furnishings from parlor clock to cook stove for indoor house scenes set in the studio; desks and typewriters for office scenes; carriages for street scenes; and revolvers and black masks for the bandits in the mountains. To obtain the articles needed for the production of a reel of film each week is a task requiring one man's attention. Once used, such articles as are likely to be used again are stored in the "property room." Unless the property man is systematic by nature, the property room soon will look like a junk shop. Costumes aside from the ordinary street dress of the actors also will be found in the property room, including particularly uniforms for policemen and messenger boys, caps and aprons for the parlor maids, and freak clothing for the comedian. The property man is the producer's assistant. Seamstresses, tailors, carpenters, and local storekeepers are in turn the assistants to the property man.

Actors. The best source for obtaining actors is the dramatic employment agency. Experienced actors are desirable, even for the minor parts, for the producer as a rule has no time for training the amateur. The custom is to employ actors for a day at a time only, the standard price being five dollars per day. One day the producer may need three or four actors, the next day twenty. In producing a drama occupying the producer for a week, he may require the leading characters for four days of work, a few minor characters for two days (one day in the studio and one day in the field) and a dozen more actors may be needed for a single scene requiring, with all rehearsals, but an hour or two.

Stock Companies. Some actors seem to have an inborn faculty for expressing thought without words, others cannot catch the trick. The producer quickly recognizes this pantomime ability in an actor employed by chance, and lists such an actor for service in the more important characters of his productions, even placing a few such actors upon a fixed weekly or monthly pay instead of employing them at the day rate with irregular service. The group of actors thus employed continuously is called a *stock company* and is supplemented by as many more actors for a day or more as may be needed for any picture. To distinguish between the stock actor and the transient, the latter is called a *supe,* an abbreviation for *supernumerary.*

Starring an Actor. For general production of pictures, continuous use of an actor in all pictures becomes objectionable to an audience. Most emphatically is this so when in two half-reel pictures the same actor takes part in the two reels The young wife who just fainted in her husband's arms at the bedside of her dead child appears on the same picture screen after a quarter-minute title as giddy sixteen flirting with half a dozen beaux. On the dramatic stage, such use of an actor is not objectionable, but motion pictures, from the fact that the scene sets are so realistic, lead the spectator to accept the actors also as real and thus add another to the burdens of the producer.

On the other hand, an actor may be "starred" in motion pictures as upon the dramatic stage. His name in the picture title will introduce him to the audience, and when his name is seen again in a title the same actor will be expected. If "Sammy at Niagara Falls" is successful on Sammy's part, the spectator will be pleased to see another title reading, "Sammy at Saratoga," "Sammy Inherits a Fortune," "Sammy Captures a Burglar," or "Sammy's First Love Affair."

Rehearsals. In the case of scenes set in the studio, it is most convenient to set the stage complete and to set the camera also in readiness. The rehearsal then is made in full dress upon the fully set stage, and when the scene is creditably performed the camera is started and the scene repeated. If the scene is difficult to reproduce, two negatives should be taken. If any flaw in the action occurs, or if the producer thinks that some variation would improve the scene, the scene should be retaken, the two scenes then being viewed and the best selected when criticising the proof copy of the film. On a scene of one minute in duration, the cost of repeating for the second negative is only two dollars for negative film, the stage set and properties being of course already at hand and the actors already rehearsed.

In the case of scenes set in natural settings, many parts of the action of the leading characters may be rehearsed before going into the field. Such rehearsals will shorten the time required in the field, and as weather conditions sometimes change suddenly, the saving of time is well worth considering.

In the street scenes where a city or village street is used, the

SCENE FROM PHOTOPLAY, "THE TEMPTRESS"
Courtesy of *Independent Moving Pictures Co., New York*

THE CONTEMPLATED SUICIDE PREVENTED BY THE BURGLARS
Scene from Photoplay, "A Good Turn"
Courtesy of *Lubin Manufacturing Company, Philadelphia*

action required should be thoroughly understood by all actors involved, and completely rehearsed if of a nature to make rehearsals possible, Fig. 9. Any rehearsal in the street will gather a crowd of onlookers, and the longer the rehearsal the larger the crowd. Even the setting up of the motion-picture camera on its tripod is in itself an invitation for a crowd to gather around it, and some of them will persist in trying to get into the view. The passing policeman usually will help, but the scenes, if any, must be short on a busy street. City ordinances usually prohibit the making of "commercial" motion

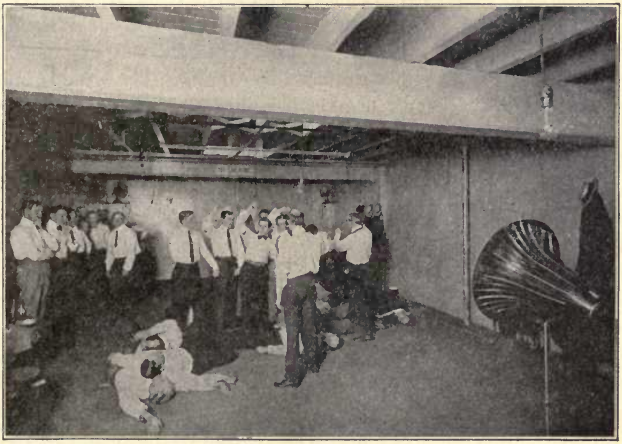


Fig. 9. An Indoor Rehearsal for an Outdoor Scene

pictures in parks or boulevards. A blind camera, in a wagon which may be stopped at the curb unobtrusively, and two or three actors fully rehearsed, may "put on" a street scene completely and have it photographed and finished before passers-by realize what is being done, or even without their knowledge at all, even utilizing some of the street traffic as a part of the scene.

Producing a Drama. To produce the drama, "A Midnight Cupid," the scrip of which has been given, the producer would classify his scenes into "studio" and "field" work, as follows:

Studio Scenes: CM room, Scenes 2, 3, 5, 7, 26. Parlor, Scene 4. Cottage bedroom, Scenes 19, 21, 24.

Field Scenes: First park set, Scene 1. Second park set, Scenes 6, 16. Store set, Scenes 8, 14, 17. Cottage set, Scenes 9, 10, 15, 18, 23, 25. Field set, Scenes 11, 12. Street set, Scenes 13, 20, 22.

Reviewing these for characters, the four principal characters and three men for minor parts will make all field work with the addition of "children playing in extreme background" in Scene 14, and Scene 6, which requires the two servants from the studio scenes; the farmers cannot double for the servants because they appear together in Scene 26.

Motion Scenes. Scene 4 requires a bunch of troublesome actresses and a large expense for wages for a single scene; if possible, it should be made when the bunch of girls are in the studio in conjunction with the scenes of another drama. By working this Scene 4 into the routine of another production having a parlor scene with the same scene set and actresses, the expense will be reduced and the producer's time will be economized.

Aside from Scene 4, all scenes should be made in continuous work. The studio being set for the club man's rooms, Scene 26 may be made first. This scene being made, the actress who played "woman aged 40" and the actor who played the "minister" is dismissed. The two "well-dressed men" may be dismissed, or they may make up promptly for grocer and policeman if the producer desires them to double in the drama. Time is allowed for them to make up for the new parts while Scenes 2, 3, 5 and 7 are being enacted before the camera with the same stage setting used for Scene 26.

Studio work for the drama now will be completed by resetting the stage for the cottage bedroom, Scenes 19, 21, and 24, the actors required being only the three leading characters, CM, G, and GF. These three scenes may be made before Scene 26, or after return to the studio from the field work, according to the producer's convenience.

The producer now takes into the field the four major actors, a policeman, two servants, two farmers, the grocer, and children for Scene 14. Scene 6 is rehearsed and performed before the camera; the two actors taking the part of servants are then dismissed. Scene 16 follows Scene 6 without permitting the tramp to rise from his position on the bench, the action of the two scenes being substantially continuous, but the camera lens being capped for a foot of the film to make a break in the negative between the two scenes when the negative is developed.

With a slight change in camera stand, Scene 1 is produced, and the actor taking the part of the policeman may be dismissed.

Proceeding to the village where the natural scene settings have been selected or are known beforehand to exist, the outside of the village store is taken first, Scenes 8, 14, and 17 being produced in order. The children now may be dismissed. The street set may be made next, making Scenes 13, 20, and 22 in order. Next the cottage set, making in order Scenes 9, 10, 15, 18, 23, and 25. Then the field set for Scenes 11 and 12 completes the action scenes of the drama. The scenes have been made in this order: 4, 26, 2, 3, 5, 7, 19, 21, 24, 6, 16, 1, 8, 14, 17, 13, 20, 22, 9, 10, 15, 18, 23, 25, 11, 12. The titles are yet to produce.

Review and Criticism. When the negatives have been developed, a print is made from each and all are spliced together in the order in which the scenes occur in the drama. The complete drama, in action scenes only, is projected for the criticism of the producer and others, including perhaps the author. The result of this criticism in some cases may be that the entire production is rejected, even the story being condemned as unsuitable for a motion-picture subject, or the producer may be required to reproduce the entire drama or certain parts of it. Perhaps some actor is judged unsuited to his part and all scenes in which he has appeared must be retaken with another actor substituted.

Padding. When making each scene, the producer had before him a schedule for the length of each scene in the drama to produce the total length required. In the review and criticism, some scenes may be cut in length and others omitted for cause. If this reduces the total length of action scenes below the required amount, scenes may be substituted to fill out, or the remaining scenes may be left a little longer than their predetermined or required lengths. This is "padding" the film. As an example of what might be done at the risk of spoiling a good film picture, "A Midnight Cupid" might open with the village cottage scene setting, girl despondent talks to father, brings paper and pen, father writes, then show title the letter which the tramp reads in Scene 1. A scene of the tramp's troubles seeking food and expressing hunger may be inserted between Scenes 1 and 2.

Between Scenes 7 and 8, scenes showing the club man en route to the country may be inserted, and between Scenes 25 and 26, scenes of all the characters en route might be added. Distinction may be drawn between a scene added to lengthen the film and a scene added for the purpose of strengthening the telling of the story, only the former being "padding."

Rewriting. The scenes and their order being determined, the producer must correct the synopsis and perhaps other parts of the scrip to fit the completed drama if any correction is necessary. Particularly in the review and criticism is the matter of titles discussed, and titles in correct and final form are determined. In the corrected synopsis, the length of each scene and of each title is noted.

Titles. The titles are made by the producer or under his direction and are given to the photographer to be done into film. The title is painted, printed, written, typewritten, or drawn, or made of movable letters arranged upon a support and removed after photographing to be rearranged for other titles. The size may be anything desired. The length of film for a title should be proportioned to the number of words in the title, being thus proportioned to the length of time which the spectator requires to read it. Two feet is enough for a single word, and a foot per word may be taken as a rule for titles longer than half a dozen words.

A sign writer who personally prefers a full arm movement would paint the titles on a sheet probably 4½ by 6 feet. A sign writer who prefers to use a small brush and a wrist movement would work on cards probably 18 inches by 24 inches. In either case, black paint on a white background may be produced as such in the finished film picture, or it may be reversed by the photographer.

A very satisfactory title is produced by setting up the words with printer's type and printing the title upon a printing press. In such a case, in order that a sharp photograph may be made, the original should be at least as large as 6 inches by 8 inches.

Where movable letters are used for titles, it is necessary only for the producer to give to the photographer a written title, or a sketch of the word arrangement desired. For titles in the nature of messages, letters, telegrams, etc., the messages may be printed with printer's script type and handed over to the photographer. Such a title probably would not be larger than 3 inches by 4 inches.

Written messages mav be prepared just as the picture screen is to show them, written by hand with black ink upon white paper. The handwriting of the message should be consistent with the character of the actor writing it, and should show creases if the message has been folded in the motion scenes of the play. For telegrams, use the regulation telegraph blank. Use a "send" blank for messages to be sent and a "received" blank for messages received. They may be written either by hand or typewriter.

Borders for titles or trademarks for titles may be incorporated into the titles by drawing or printing the title upon sheets which have been printed previously with the border or trademark.

A "reversed title" is a name given to titles having the letters show in white upon a dark picture screen. This effect is obtained directly by painting with white upon a black background, or by arranging movable white letters upon a black table, but it may be produced from black letters upon a white ground by an additional process in photographing. It is not suitable of course for messages. A reversed title is much more easily read and is much more acceptable to the audience than a title which has black letters upon a white ground. The reversed title is further improved by tinting.

Final Criticism. The titles being completed, and added or changed scenes having been reproduced, the proof for the first criticism has each scene cut to its prescribed length and proofs of the titles are cut to their prescribed length and inserted among the motion scenes in the order required by the revised synopsis. Thus, there is produced a final proof picture of the complete film as it is to be released to the public. The final proof is projected before the producer and critics and if approved it is turned over to the photographer as "copy." The photographer cuts his negative into lengths, both motion scenes and titles, splicing them together to reproduce a complete continuous negative of the approved "copy."

Whether the film be drama, comedy, travel, chase, or trick, the procedure of motion-scene production, first criticism, rewriting scrip, making titles, final proof, and approval of copy is on final criticism in substance the same.

At this point, the film picture passes out of the hands of the producer and into the hands of the salesman, or advertising manager of the producing company.

THE SALESMAN

The salesman of the film manufacturing company, or the advertising manager, as his title usually reads, has as his task the disposition of as many copies of the finished picture (as many photographic prints from the negative) as his opportunity and ability can effect.

Branches of the Film Industry. The customer of the film manufacturer is the film exchange manager, or renter, whose customer in turn is the film exhibitor. The film industry is definitely separated into three branches: *manufacturer*, *renter*, and *exhibitor*. The renter owns the picture films. He buys from the manufacturer for cash and rents the films to the owners of picture theaters for exhibition. The exhibitor owns no films, merely renting them for a day or a week from the renter; the manufacturer owns no positive picture films, merely printing from his film negatives as many copies of each picture as can be disposed of immediately to his customers, the film renters.

Selling Methods. General publicity is obtained among the renters and exhibitors by advertising in the motion-picture magazines. In the magazine advertisements, the general excellence of the manufacturer's film pictures is told, and the current film pictures just produced or about to be produced are announced by title with a few descriptive words and illustrations.

Lectures. The magazine advertising is supplemented by lectures or short stories of the film pictures. The lectures derive their name from the original purpose, which was to provide a talk to accompany the picture, explaining the story of the picture as the action progressed on the screen. While the original purpose of lectures is almost extinct, their advertising value remains and they are used by manufacturers in large quantities. Each film picture has its lecture and these are printed either separately or in a little pamphlet covering the manufacturer's output of film pictures for the week or for two weeks.

The lectures are written by the salesman or his assistants, using the corrected synopsis or scrip of the story as a guide and keeping in mind at all times the film as actually produced. At least the motion scenes of the picture should be produced and reviewed by the critics before the film is advertised for release and before the lecture is written. The writer of the lecture, having sat at the projection of the proofs for the preliminary review, will be further guided in writing the lecture by his recollection of the strongest scenes of the production. The lecture is illustrated by views of the film taken from the scenes either by clipping a small image from a copy of the proof film or by photographing the scene with a hand camera upon a larger scale while the picture is being produced. In either case, the engraver is able to produce printing blocks of the desired size for the lecture.

Lectures are mailed in advance of the release date of the film. They are sent to the magazine publishers that they may be printed in the magazines either in full or in part, for additional advertising value to the manufacturer. They are sent to the film exchanges that the renters may know what pictures are promised for the advance dates. They are sent to the exhibitors that the exhibitors may be impressed by the lecture that the film is especially suited to their particular audiences and that the exhibitors may ask the renters for the picture and the renter thus be obliged to buy the film from the manufacturer.

Release Dates. The routine of manufacturing and selling motion-picture films can be compared very closely with the routine of printing and selling a newspaper or magazine.

The amusement business is established upon a weekly basis. In theatrical circles, a year is spoken of as fifty-two weeks, and a day one-seventh of a week. The big theaters change their bills at the end of the week, and the vaudeville programs are changed weekly Similarly, in the motion-picture theater, the program is made upon a weekly basis, the film renter makes his schedules upon a weekly basis, and it best suits his convenience to receive his films from the manufacturers upon a weekly schedule. As the business man gets his newspaper every morning, so the prominent "daily change" motion-picture theater gets its new film every morning from the renter, who, in turn, gets films every morning from the various manufacturers. Orders are placed by the renter on a basis of weekly deliveries, that his schedule may run smoothly. Monday morning brings a reel from manufacturer *A*, Tuesday a reel from *B*, Wednesday a reel from *C*, Thursday another reel from *A*, Friday another reel from *B*, and Saturday a reel each from *D* and *E*. These deliveries are repeated weekly, giving a constant schedule of seven reels per week, combining the product of several manufacturers.

In view of the deliveries required by his customer, the renter, the manufacturer is obliged to issue his pictures as regularly and as punctually as a publisher issues his magazine to the newsdealer. Each film manufacturer, therefore, establishes one or more release days for each week, according to the number of reels of film which he will manufacture per week, and advertises that a full reel of film will be sold or "released" upon each of his release days.

Advance Shipments. It has been found convenient to release a picture in all parts of the United States upon its release date, and this is accomplished by advance shipments to discount the time in transit, and by shipments further advanced to discount the likely delays in transit. A New York manufacturer will ship his pictures to San Francisco customers seven days in advance of his release date; to Denver or New Orleans customers five days in advance of his release date; to his Chicago and St. Louis customers three days in advance; to Philadelphia and Boston customers two days in advance; and will deliver by messenger to New York customers on the evening before the date of release. In the case of the distant shipments, the films should arrive two or three days ahead of the release date, but the renter is honor bound to issue them to the exhibitor only on and after the release date. In case it comes to the attention of any manufacturer that any renter is violating the release date, the advance shipment for discounting delays in transit will be withheld.

Factory Schedule. A safe schedule for insuring the release of the picture film to the renter promptly upon the release date carries the beginning of the work of making the film back to a date many weeks before release. A picture to be released on May 6, if manufactured in New York, must be shipped to the San Francisco and Los Angeles customers a week in advance, on April 29. The photographer must have time in advance of this to enable him to print the pictures from the negative, so the approved "copy" of the film must be delivered to the photographer on April 22, two weeks in advance of release date, that he may fit his negative to the "copy" and begin printing in time for the west coast shipment. Inasmuch as the final criticism may require changes before the "copy" is approved, the projection of the picture for final criticism is set for April 15, three weeks in advance of release date. Between projection of the motion scenes for preliminary criticism and projection for final criticism, one week is not sufficient for remaking condemned scenes, producing padding scenes, rewriting the scrip and making the titles. Particularly in view of the possibility that the entire picture may be rejected, an interval of three weeks is none too short between preliminary review and final review in the ordinary progress of the factory. The date for preliminary criticism is set for six weeks in advance of release, or March 25 for preliminary criticism for the May 6 release. For ordinary productions, give the producer a latitude of two weeks for his motion scenes, and two weeks preceding for preparation of his scenery and properties, taking the delivery of the scrip to the producer back to ten weeks in advance of release date, or February 25, for the release of May 6. Still back of this date is the writing, criticism, and acceptance of the original scrip. Some pictures, particularly trick pictures, may require many weeks for the production of the motion scenes.

In contrast with this is the story told of an eastern factory, that an actor in the noon hour suggested to the producer a thought for a comedy, that the producer dropped the work in hand and had the first scene of the new comedy on at two o'clock the same afternoon, and scenes were completed for a full comedy reel the following day. In contrast also is the method of a producer who habitually worked without scrip or scenario, producing only his own creations, direct from brain to film.

Sales Contracts. The usual order accepted by the manufacturer from the renter is an order for a predetermined number of reels per week—usually one copy of each picture produced by the factory. Such an order gives the manufacturer advance knowledge of the quantity of his output and it is by such orders only that a manufacturer is enabled to work upon so close a schedule as the one cited—giving but two weeks between the final approval of the "copy" of the picture to the release date. If it becomes necessary for the salesman to exhibit an advance copy of the finished picture as a means for getting orders for the films, several additional weeks must be inserted in the schedule between the final approval of the "copy" and the date of the release of the film.

Title Posters. To advertise his program to the passers-by, the theater manager—or "exhibitor," as he is known in the trade—displays the titles of his pictures in front of his entrance. The salesman for the film manufacturer provides for attractive posters for the films released, either by furnishing them to the exhibitor directly through the film exchange to whom the salesman sells the film, or by providing necessary information to title poster companies to enable them to offer attractive title posters to the exhibitor.

REPRODUCTION

THE PHOTOGRAPHER

If the *factory* is to be considered as distinct from the *studio,* and from the *office,* then the office is the department of the salesman, the studio is the department of the producer, and the factory is the department of the photographer. "Factory superintendent" perhaps would be a suitable title for this photographer, for he does but little of the photographic work with his own hands. The divisions of his factory taken in the order in which they become useful in the making of a picture film, are as follows:

Divisions of the Photographic Factory. The raw sensitive film is purchased cut to size and packed in tin cans. A fireproof iron safe or a fireproof vault for film storage holds the film until needed. From the vault, it is taken to the perforating room, where holes are punched in the edges Thence the negative film goes to the camera man, who is the photographer's employe working under orders of the producer. From the camera man the exposed film goes to the developing room, where it is developed into a negative. Then titles are made. Scenes and titles being finally approved and spliced up according to "copy," the film negative goes to the printing room and supplies of positive film also go from the perforating room to the printing room, where the positive film is printed from the negative. The negative, after all prints are made, goes to the film storage room permanently. The printed positive film goes from the printing room to the developing room which developed the negative, then to the washing room, then to the drying room, and when dry to the inspection and splicing room and again to the fireproof storage vault until the day for packing and shipment. In brief, the divisions of the photographer's factory are film storage, perforating, camera, developing, title making, printing, washing, drying, inspecting, and shipping. The strip film is bought ready for perforating.

The total task of the photographer—or "factory superintendent" or whatsoever title he may bear in various film manufacturing plants—is to produce a creditable photographic film picture when the producer has enacted the scenes and has written the titles. This task requires the photographer to have his assistant, the camera man, present when the producer enacts a scene, and leaves the responsibility upon the photographer—through his assistant, the camera man—for the proper photographic record of the scene upon the negative film of the camera. The division of responsibility at this point is logical. If a negative is lost because the camera man used the wrong stop in the lens, the failure is photographic in nature, and the photographer is to blame because of the incompetency of his assistant. From this point to the delivery of the film for shipment, the processes are wholly photographic. The photographer assigns his camera men to the producer as demanded, providing them with negative film, and delivers proof prints to the producer for criticism. From approved proofs and picture "copy," the photographer prints finished film pictures as requested, and delivers them by shipping them under the salesman's orders.

Raw Film. *Composition.* The sensitive film before use in the camera consists of a long narrow strip of celluloid coated with a gelatine photographic emulsion. Its manufacture is distinctly in two parts, the making of the celluloid strip and the making of the sensitive emulsion and coating the celluloid strip with the emulsion. Neither the making of the celluloid nor the coating should be attempted except by skilled workmen in a thoroughly equipped factory.

Manufacture. Celluloid is made from pyroxylin and camphor, the pyroxylin or guncotton being made from raw cotton by treating it with nitric and sulphuric acids. Sulphuric and nitric acids are mixed in practically equal quantities, the raw cotton is dipped until saturated but not allowed to dissolve, then is thoroughly washed and dried. By this process the cotton has been transformed into guncotton, an article very explosive in nature, but not different in appearance from the original raw cotton. The camphor is dissolved in alcohol, making a saturated solution.

A layer of dry pyroxylin is placed in a tank and about one-half the quantity of camphor solution is sprinkled over it, then pyroxylin, then camphor, and so on. The pyroxylin dissolves in the camphor solution and celluloid is formed in lumps which sink to the bottom of the tank. The lumps of celluloid are worked between rollers, cold and hot, and pressed in hydraulic presses and dried.

The celluloid stock is worked into thin strips for motion-picture work, the strips being 1/200 of an inch in thickness. The width and length may be anything desired, say 22 inches wide by 200 feet long.

Coating. The emulsion for coating the film is of two kinds, slow for prints and fast for negatives, a bromide emulsion for the slow and a nitrate emulsion for the fast. The emulsion, made as for photographic dry plates or hand-camera films, is placed in a coating machine having an emulsion hopper and a slit to feed the emulsion upon the celluloid. The 22-inch strip of celluloid is passed at a uniform speed through the machine and under the emulsion slit, receiving a uniform coating as the emulsion flows out upon it. The wide strip of film is dried and taken through a cutting machine which splits it into strips $1\frac{3}{8}$ inches wide and 200 feet long. The narrow strips are rolled up and packed in round flat tin cans, sealed with adhesive tape, one strip, or 200 feet of film, in each can. It is now ready for delivery to the motion-picture manufacturer

Non-Inflammable. The celluloid base of the motion-picture film is highly inflammable, although not explosive in that it will not take fire unless a flame is applied to it or it is heated to a very high temperature to start combustion. The heat of the projecting arc concentrated upon the film in the film window of the projecting machine is sufficient to ignite it. When ignited, it burns rapidly

Many experiments have been made either to discover a substitute for the inflammable celluloid for use in motion-picture work, or to discover some modification of the process of making celluloid which would render it less combustible. By adding amyl silicate or methyl silicate to the vat in which the pyroxylin and camphor are combined, a sufficient quantity of silica may be added to the celluloid to reduce its inflammability so that it will burn very slowly, if at all. The addition of calcium chloride to the celluloid compound also produces a similar result. The finished mass of new celluloid while still soft may be treated with stannous chloride, rendering it less easily combustible.

A non-inflammable product made by combining camphor with an acetate cellulose instead of with a nitrate cellulose, or pyroxylin, has been used widely as a substitute for the inflammable celluloid strip for motion films. This is the "N. I." commercial film, and gives satisfactory service for a short life. Its objectionable point is that with age and the heat of the projecting arc it shrinks to some extent and becomes somewhat brittle.

Storage of Film. The greatest care must be taken in selecting a place for the storage of the raw film, as also for the storage of the finished pictures before shipment, and for the storage of the film negatives, the most valuable of all, particularly during the period between preliminary approval and the release of the picture. The storage room must be so situated and constructed that the film will be kept safe from flames and will be kept cool. When warm, celluloid gives off explosive gases rapidly. A vent pipe for such gases may be formed by a pipe of small size leading to the open air and guarded with steel wool or gauze to prevent backfiring.

Fig. 10. Specimen of Positive Film

Perforation of Film. The standard perforation is four holes per picture, or rather four pairs of holes per picture. Each hole is approximately $\frac{1}{16}$ inch by $\frac{3}{32}$ inch, spaced along the edges of the strip of film at a distance of $\frac{3}{16}$ inch apart, making four holes on each edge for each $\frac{3}{4}$-inch motion-picture image. The photographic images being 1 inch wide, and the film strip $1\frac{3}{8}$ inch, the pictures being also in the middle of the strip, there remains a margin of $\frac{3}{16}$ inch on each side of the strip for the feed holes. The perforations are placed in this margin, not centrally in the margin, but against the side of the image to leave as wide an edge of celluloid outside of the perforations as possible to strengthen them against breaking out to the edge. In the illustration of a specimen of picture film, Figs. 10 and 11, the perforations seem to encroach upon the photographic images. Indeed, in the projected picture upon the screen, the edges of the perforations sometimes are seen at the side of the picture because of a lack of proper centering of the film in the projecting machine.

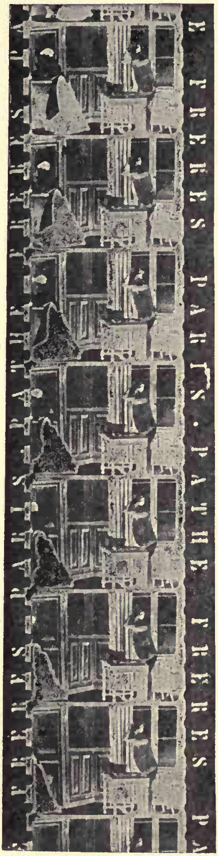


Fig. 11. Negative Film. Motion is shown by positions of lady with black skirt and white apron. (Film shows reverse colors.)

Shape. The three shapes of perforation commonly used are known as *round*, *square*, and *barrel*. They are illustrated in Fig. 12. The square and barrel holes seem to give longer life to the film than the hole having the round form. The shape of the tooth in the projecting machine which enters the film perforation and by which the film is pulled through the projecting machine should determine the shape of the hole. The tooth most commonly met has a flat pulling face, and this pulls best against the flat surface edge of the hole offered by the shape of the square or barrel perforation.

Spacing. The sprocket method of feeding the film allows some latitude in distance of perforations, and thus cares for slight inaccuracies in the perforating machines, and for the variation due to shrinkage of the film with age or with its treatment in the processes of development and drying after leaving the perforator. The spacing in the perforating machine should be $\frac{3}{16}$ inch per hole, and it should be uniform. Careful experiment has shown that the films whose sprocket holes wear best are those whose sprocket holes are most uniformly punched, regardless of whether they have maintained their original distances or have been subjected to change by development processes or by age. If the holes are not uniform, one hole edge will get more than its share of pull from the sprocket teeth, and that hole will break out, its neighbors then getting an excess strain and breaking in turn until the film must be cut and spliced. The splice in passing through the film gate places an abnormal strain upon the edges of the perforations in advance of it and

Fig. 12. Shapes of Film Perforations

which have to pull it through the gate. Thus the trouble started by uneven punching is cumulative and shortens the life of the film.

Perforating Machines. Self-feeding or automatic punch presses for punching small blanks out of sheet metal may be seen in large machine shops. When provided with proper punches and dies they become suitable for perforating motion-picture film. When the punches are of the *reciprocating* type, a group of eight punches work vertically above a plate having holes to receive the punches and having guides for the unperforated strip of film. Associated with the punches are two "pilots," tapered fingers, which come down with the punches and pass into the last holes of the film strip, that the distance from the last holes to the new holes about to be punched may be exact. An intermittent feed device, similar to that of the camera or projecting machine, works into the holes of the perforated end of the film and pulls it forward one picture length between the strokes of the punch. Punches of this type may be operated at speeds of 500 to 1,000 feet of film per hour. Only one strip at a time is punched.

In the case of *rotary* punches, two drums are built, one of which has in its face recesses corresponding to the holes of the finished film and the other of which has teeth to match the recesses of the first drum. The teeth are of such length that they reach to the edge of the recesses of the companion drum but do not enter. The drums are revolved in unison and the film strip is passed between them. Revolving brushes keep the punched-out pieces from following around the drums and entering again. Rotary punches are of high capacity, being able to perforate film at a rate of 5,000 feet or more per hour. They are more likely to get out of accurate adjustment than the reciprocating punch, and are more difficult to sharpen when dulled by service.

Perforating Room. The perforating room is a darkroom, photographically dark while the perforating machines are working the film. It is only when all film is safely shut in the tin cans that the white light may be turned on or the door opened. It has a "light-trap" entrance, or in the wall is built a turntable with four wings, like the revolving doors of a store or office building, encased light tight, with a window into the turntable inside the darkroom and another outside. By this turntable, a few cans of punched film may be passed out on demand without waiting for the punching machines to finish their strips of film to permit the door to be opened.

Camera Man. Only a photographer who has demonstrated his ability to make good negatives with the fixed camera under varying conditions should attempt to qualify for the position of camera man with a motion-picture factory. Upon the camera man, as representative of the factory photographer, rests the responsibility for getting a good negative of the scene enacted by the producer. A photographer who can make a good fixed camera negative of the scene setting can acquire easily the necessary skill in turning the camera crank at a uniform rate of speed, and then is fully competent to make a thousand motion-picture images of the same scene while the action of the scene is taking place.

Camera. The professional motion-picture camera should have the following features: A *well-balanced intermittent movement,* turning smoothly and uniformly in all crank positions; an *adjustable shutter,* adjustable to give a variable ratio between the "open time" and "closed time" of the film window for each revolution of the shutter, that is, for each picture made upon the film strip; *two or*

THE SLAVE AND HIS SWEETHEART EXCHANGE SIGNALS
Scene from Pathé film, "The Slaves' Revolt"
Courtesy of *Pathé Frères, New York and Paris*

SCENE FROM "CUPID'S CONQUEST," BY GAUMONT
A Colored Fantasy of Unusual Richness in Staging and Originality of Plot
Courtesy of the *Kleine Optical Co., Chicago*

more lenses fitting into the same mount or flange ring, the lenses being of different focal length for changing the angle of the view or the size of the images in the film window and for decreasing or increasing the depth of the field for action in the scene; *focusing mount for the lenses*, either having each of the lenses in its own focusing mount or preferably having a single focusing mount into which any one of the different lenses may be inserted; a *sliding lens board*, equivalent to the rising and falling front of the fixed camera; *detachable light-tight film boxes*, equivalent to the dark slides of the fixed camera preferably of such construction that the film boxes may be interchanged without opening the mechanism compartment of the camera; a *trick picture crank;* a *reversing crank* or a *reversing tripod socket;* a *detachable main crank* or preferably a *folding main crank;* a *level;* a *finder for panoraming;* a *finder for focusing window*, for focusing without opening the camera; an *indicator* showing the amount of film used and unused at any instant; a *speed indicator* showing at any instant the speed (in pictures per second) at which the camera is being turned; a *film marker* which may be operated from the outside of the camera to mark upon the film an indication of the position of the film window upon the film; a *stiff tripod with panoram head;* a *carrying case*. In addition to providing for the panoraming movement or horizontal swinging movement of the camera upon the tripod, the tripod head sometimes provides for a rocking movement of the camera vertically.

In size, motion-picture cameras vary greatly, even when built to carry the standard size film, $1\frac{3}{8}$ inches wide, and the standard quantity of a 200-foot reel. The comparative size of camera and man is seen in several of the figures. The Urban camera is about 18 by 18 by 6 inches. Others have been made showing a front 6 by 10 and a depth of 14 inches. Some cameras, as the Urban, carry the film boxes inside the camera case, while others attach the film boxes to the outside of the case, thus making the size of the camera case alone seem deceptive when given in figures. The weight of a camera will vary from eight to twenty pounds.

Film Movement. Successful cameras have been built by constructing a light-tight box for the motion head of a projecting machine. Such an arrangement fills all requirements although it may make a bulky camera. The limitations in building a film shift for a camera are less rigid than those placed upon the projecting machine, because of the shorter period of rest. In the projecting machine, the film must be at rest for at least eighty per cent of the time, and must be shifted in the remaining twenty per cent of the picture interval. In the camera, the intermittent mechanism may be such as to use forty per cent of the picture interval in movement if desired.

The margin of safety for a good picture in a camera is of greater importance than in a projecting machine. If the projecting machine is out of order, it is known immediately by the result upon the screen, and the machine is adjusted. If the camera is in any way out of order, it is known only when the films are developed at the end of the day's work, with the result that the day's work must be done over by the producer.

The film in the camera must be motionless during the interval of exposure to the lens. The claw type of intermittent movement seems well adapted to this end, since the claws may advance into the perforations, seize and pull down the film and retire from the perforations entirely, leaving the film entirely out of contact with the film shifting mechanism and, therefore, to the greatest degree unaffected by the driving devices which, were there any actual contact between the driving devices and film, might cause a slight movement. During the period of rest of the film the claws return to the position from which they advance into the perforations to give the film its next step, and during this interval the exposure of the film to the lens is made. That the claw-shift mechanism subjects the film to greater wear than the sprocket movement becomes of less importance in the camera than in the projecting machine, since the film is run through the camera but once.

In addition to the Edison camera, using the sprocket with perforated film strip, and the Urban, Gaumont, and many others using the claw movement with perforated film strip, all of which use intermittent movement of the film, there are two other classes of cameras—those which do not use the intermittent film movement and those which do not use the perforated film. The object in the use of cameras avoiding the perforated film and the intermittent movement usually is found in an intent to avoid patents bearing upon those features. The Bianchi camera, used by Columbia licensees, makes pictures upon a continuously moving film. The

Hamacek camera uses an unperforated film, the film being perforated after development of the negative.

Loading Film Holders. Each film holder consists of a black box of thin wood with door and spindle. One side of the box opens as a door, either hinged or entirely removable. The spindle or hub passes through both sides of the box, back and door, turning in journal boxes carried by the back and the door, and usually being removable from the box merely by lifting out when the door is open. The hub has a clip or slot for attaching the end of the film, so that the film may be wound upon the hub when the hub is turned. Upon the end of the hub—usually upon that end which projects through the back of the film holder, but in the case of the removable hub the two ends should be alike—is a key way whereby the film movement of the camera may engage the hub and turn it to wind up the film. The key is a slot or a pair of holes for pins, and in the camera at the position for the take-up film holder is a key corresponding to the key way.

The negative film will be supplied from the factory storage vault in rolls of 200 feet, perforated, rolled with an open center a little larger than the hub of the film box of the camera, and packed in a round, flat tin can sealed with adhesive tape. In loading an empty film holder, it is necessary only to open the door of the holder, open the tin box (in the darkroom), drop the roll of film over the spindle, pass the end of the film through the slot of the holder, and close the holder.

In reloading a film holder containing exposed film, the processes are different, depending upon whether the holder has a removable spindle or hub, and whether an extra hub is at hand for reloading the removable hub type of box. When the removable hub type of film holder is used, the factory should provide an extra hub with each roll of negative film, packing it in the tin box in the hollow center of the film roll. To reload, the camera man opens (in the darkroom) both tin film box and camera film holder, removes the new film from the box, lifts the exposed film from the camera film box to the tin box without removing the hub, upon which the film is wound tightly, and seals the tin box with the adhesive tape. He then fits the new hub to the film holder, drops the new roll of film over it, threads the end of the film through the slot, and closes the film holder.

In reloading the film holder in which the hub is not removable, the camera man must have a film winder, winding the film out of the holder, then changing the new roll of film from the tin box to the film holder, and then the exposed film from the winder to the tin box.

Exposed and Unexposed Films. Safeguards are necessary to avoid the accidental exposure of the same film twice in the camera, either from the mistake of putting an exposed film holder back in the camera or from the mistake of reloading an exposed film from its tin box back into the film holder and thence to the camera. In short, there should be some signal to indicate that the roll of film has been exposed, similar to the turning of the dark slide of a plate-holder.

The outside end of an unexposed roll should have its corners clipped to facilitate threading through the camera when loading. The inner end should be left square. A roll with the outer end square, therefore, is an exposed roll.

When the film holder is loaded, the leading end of the film is threaded through the slot of the holder, and projects to be pulled out and threaded up in the camera. When the roll is exposed, it is wound up completely into the take-up holder, so that the end of the film does not extend from the exposed holder.

In a camera having holders with removable spindles or hubs, the exposed roll of film will have a hub in its center upon which the film is tightly wound. The unexposed film will have the hub in the tin box, perhaps, but the film will not be tight upon it.

In a camera without removable spindles, a roll of film which has been removed by the camera man in reloading, probably will have a different size of center hole from the roll received from the factory film storage room.

Tin boxes containing unexposed negative film in the factory storage room should be wrapped in paper and the wrapper pasted shut so that the paper must be torn to get it off. When reloading film holders, the camera man does not wrap the tin cans of exposed film, hence the only fresh film the camera man has is the film in the wrapped boxes and in the film holders with the leading end sticking out.

In addition to all other precautions, the exposed film should be sent in to the factory as soon as exposed, but even then the factory may send back an exposed roll to the camera man, and danger signals should be watched for.

For studio work and field work close to the factory, film holders may be loaded in the factory darkroom. Where the camera man is in a distant city or still worse in the country, it may be necessary to transfer film from tin cans to camera film holders when no darkroom is available. A bedroom closet will serve if an assistant outside will hang clothing or bed clothing over the cracks of the door until the camera man inside can see no light. Kneeling on the floor at the bedside with the hands (and films and boxes) under the covers, either at night or with shades drawn and a bed cover hung over the window, the camera man may work by touch. Have an empty tin can and as a first operation transfer the film to the can and as a second operation transfer the film from a new can to the film holder. In the field, if the emergency arise, take off the coat and shove the arms through the sleeves the wrong way, changing the film inside the coat. An assistant supplies the film and boxes to the hands inside the coat, and muffles it further by any available clothing. Get in the deepest shadow available. For all these emergency methods it may be borne in mind that the roll of film is largely self-protecting. On the sides of the roll, the light must penetrate 3/16 inch before reaching the latent images, the inner layers are light-struck by the acts of loading the camera and they serve to protect the following layers, while on the outer layers there may be left several layers of unused film for protection if the emergency reloading is known in advance.

Loading the Camera. The loading of the camera is an operation designed for daylight work. It is no more difficult than threading a film through a projecting machine. The full take-up film holder is removed. The empty film holder is taken from the feed position and fastened securely in the take-up position, the hub being connected with the mechanism of the camera, and the handle given a few turns to ascertain that the hub is turning properly to take up the exposed film. A loaded filmholder then is placed in the feed position and the end of the film pulled out to reach the feed mechanism. A brush should be attached to the inside of the camera door by a spring clip, and the inside of the camera, particularly the film window, should be brushed carefully to remove minute particles of celluloid or other dust particles left by the previous roll of film in passing through the machine. The new film then is passed through the upper steady feed, through the intermittent feed, and through the lower steady feed, to the take-up film holder, passed through the slot of the holder and attached to the take-up hub. The take-up holder is closed, and the handle is given a turn to make sure that the film is feeding properly and that the take-up holder is working properly. The camera case then is closed and the handle is turned once or twice as required to wind past the film window that length of film between the feed film box and the film window which has been light-struck by exposure during the loading of the camera.

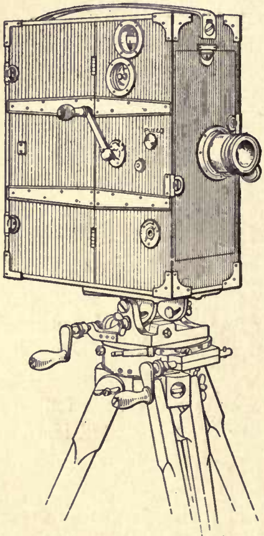


Fig. 13. Urban Camera

In Fig. 13 is shown the Urban camera, with panoraming and elevating or rocking tripod head. The door at the left on the side gives access to the film holders and feeds for reloading the camera; the removable panel in front gives access to the intermittent mechanism. Fig. 14 shows the Gaumont camera, open. In this camera the upper and lower constant feeds are taken from the same sprocket, the intermittent feed mechanism being enclosed in a dust-proof box at the front of the camera. The feed and take-up reels are external to the camera body and have a very large capacity, 500 feet.

Camera Man's Duties. *Taking the Picture.* To set up his camera when instructed by the producer, to include the scene pointed out by the producer, to begin turning and to stop turning when told by the producer, to keep his camera in adjustment, to keep an ample supply of film for the producer's requirements, and to turn over to the factory a correctly exposed roll of film having upon it a record of the producer's scene from the word "start" to the word "stop."

Turning Crank. At the top of the illustration of the Urban camera is a round window in which a finger moves over a scale marked 10-12-14-16. When the handle is turned, this hand indicates the number of pictures per second which are being taken. The usual speed is fourteen pictures per second. Turning the crank at a uniform speed of fourteen pictures per second, without variation in the speed and without shaking the camera upon its tripod,

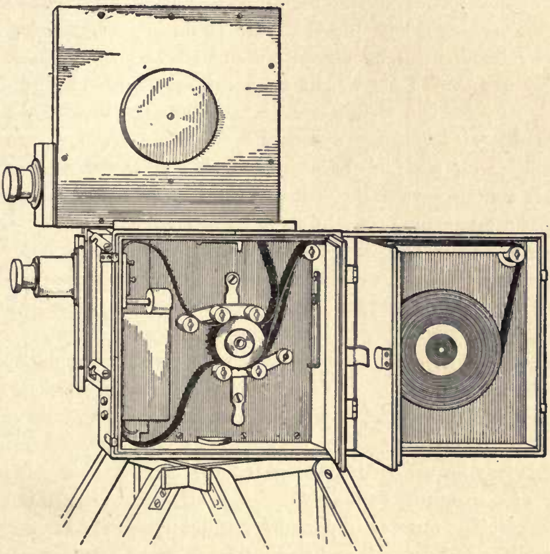


Fig. 14. Gaumont Camera

can be done only after much practice. Variations are liable to occur in every turn, the inexperienced camera man turning faster as the handle comes down and not so fast as it is passing backward at its lowest position. They are liable to occur also by steady increase or decrease of speed, starting a scene at fourteen and finishing it at the rate of ten or eighteen pictures per second. When the actors are playing their parts in the scene, the producer is prompting them and the action becomes interesting or exciting, the new camera man is liable to become interested or excited also and either turn the crank so fast that his negative is spoiled or forget to turn it at all.

Practice may be had by turning the camera crank without film. The length of exposure is dependent upon the speed of the crank. If the crank is turned faster as it comes down, the exposure will be shorter for the picture made then, and in the negative every fifth or sixth or eighth picture will be under-exposed as compared with the remainder of the negative. Such a negative cannot be used because a print from it would show similar variations and the result for the audience viewing the projected picture would be disagreeable.

The crank must be turned without shaking the camera. If the operator throws his weight upon the crank in any part of the turn, the tripod will yield slightly and change the view in the film window by shifting it slightly up or down or sideways. This shifting will occur periodically with each turn of the crank and the result is a strange waving or surging effect in the projected picture. To turn a crank uniformly in all parts of its revolution, the elbow may be placed in line with the center of the crank shaft and the crank turned with a movement of the forearm only, keeping the elbow still. In this way, the operator's weight is not thrown upon the crank and a steady rate is obtained.

The beginner must keep his eye on the speed gauge until turning becomes automatic. If there is no speed gauge, the best plan is to count while turning, and not to look at all at the action in the scene.

Cameras have been built to give three, four, five, six, or eight pictures for one turn of the crank. Four, six, and eight are in common use. The number of pictures, not the number of turns of the crank, is the end desired, and this means different crank speeds for different cameras. With eight pictures per turn—the speed most commonly met in modern professional cameras—fourteen pictures per second are obtained by turning the crank at the rate of 105 turns per minute; at six pictures per turn the crank speed required is 140 turns per minute. Many watches tick five ticks per second, 300 ticks per minute. Get a watch ticking 300 per minute and learn to count one-two-three, one-two-three, one-two-three, just as fast as the watch ticks, turning the crank one turn for every one-two-three, and the crank speed will be one hundred turns per minute, which is near the proper speed for an eight-picture camera. Count one-two, one-two, one-two, for the ticks of the watch and turn the crank of a six-picture camera one turn for each one-two. Useful practice may be had by turning the crank and holding the watch to the ear, a plan feasible even when actually taking pictures in the field. The greatest precautions must be taken by the new camera man to prevent the action of the scene taking his attention from the crank.

When the trick handle is used, it is to be turned at the same speed as the main handle, as though the full number of pictures were being taken.

To secure the best results with the panoram handle, it should be operated by an assistant, but with practice passable results may be obtained by one operator, turning the picture crank with one hand while he turns the panoram handle at a different rate of speed with the other hand.

Setting up Camera. The camera must be rigid upon its tripod, and it must be level. A level may be built into the camera case, or a small pocket level placed upon the top of the camera will serve, the level being tried both crosswise and lengthwise of the top of the camera. To "find" the view properly it may be necessary to tip the camera front up, but only ludicrous results will be obtained when the camera is not level crosswise. In the absence of a level, step back a few feet from the camera and "sight" it against the horizon line or some neighboring building. It is almost the universal rule in making pictures of dramatic action with natural settings to set the camera upon a portable platform probably 4 feet high, thus bringing the lens of the camera above the heads of the actors and of passers-by. This elevation also enables the camera man to arrange his image with the horizon line above the top line of the picture and thus cut out any signboards, fences, and houses of the extreme background.

Lens Length. The standard length for moving picture lenses is 3 inches. This gives an angle of view of about twenty degrees; a 2-inch lens gives an angle of about thirty degrees. The camera must include in its film window as much of the scene as the producer desires, and the producer must know, particularly in a natural setting, just where the limit lines of his scene are located, that he may keep his actors in the film window when they are supposed to be in the scene. More of the immediate foreground may be included in the film window image by moving the camera stand back, but where this cannot be done a similar result may be had by substituting the 2-inch lens for the regular 3-inch lens. When too much of the foreground is included, the camera may be moved forward or a 4-inch lens may be substituted. The camera man whose camera has but one lens will find himself at his wits end sometimes to include in the view just what the producer wants and no more. The most useful lenses are the standard (3-inch) and the "wide-angle" (2-inch). Lenses of 5-inch focus or longer are useful only in travel work for taking scenes and views of objects which cannot be approached closely, and for making pictures of trick or spectacular nature. Lenses of great focal length will require extension mounting tubes, since there is no bellows extension for the increase of distance between the lens and the film window.

Focusing. The motion-picture camera has no bellows, but is focused by sliding the lens in its mount. The barrel may have a rack and pinion with knob for racking the lens in and out, or the lens may be mounted in a screw flange and may be moved backward and forward by turning the lens in the mount. A limited movement only is thus obtained as compared with the movement of the bellows of a fixed camera; but in the motion-picture camera the very short focal lengths of the lenses require but small movement for their maximum adjustment for focus.

It is convenient to have the lens mount so arranged that when the lens is as far back as possible, at the limit of its motion, it is in universal focus for its largest or most commonly used aperture. By "universal" focus is meant that position of the lens in which distant objects are in focus upon the screen, nearer objects being to some extent blurred. At *f*/16, objects from the extreme distance and up to 30 feet from the camera are all in focus with the proper adjustment; with *f*/32, objects up to 20 feet; at *f*/6.3, objects up to 100 feet. The lens position for universal focus depends upon the diaphragm stop used.

In a crude camera it may be necessary to open the camera case and focus by looking directly upon the film window. The camera should have a focusing window for enabling the operator to see the image in the film window without opening the camera. This window may be either in front of the film or back of the film, and of course must be closed after focusing to prevent leakage of light to the film while being exposed by the crank. As the distance from the focusing peephole to the image in the film window is several inches, it is customary to have a lens for focusing which both enlarges the image, making accurate focus easier, and inverts the image so that the view is seen right side up.

Focusing may be done either upon the sensitive film which has been threaded through the camera mechanism, or a piece of very thin ground glass or of celluloid which has had its surface "ground" similar to ground glass, which may be placed in the film window for focusing, being removed and the film threaded up after focusing. Particularly for work in a city street is it desirable for the operator to set up his camera, get his field and focus, and be ready to turn in the shortest possible interval, and particularly for such work will the dead stop for universal focus be found desirable.

Control of Image. Aside from lens length and point of view, the operator has the sliding lens board, the equivalent of the rising and falling front of the fixed camera. The short focal length of the lenses used requires caution in using the sliding lens board, since the definition of the image is sacrificed when the center field of the lens is not used. The sliding front may be assisted by tipping the camera slightly when the resulting distortion is not objectionable.

The camera man's most powerful element of control of image is found in the selection of the point of view, and his tactful control of the producer in avoiding objectionable camera positions and in obtaining such camera stands as will lend some pictorial value to the images of the film window.

Shutter. The disk shutter is universal for cameras. A disk of thin sheet metal revolves in a plane between the lens and the sensitive film in the film window. An opening is cut in the shutter, or a part of the disk is cut away, and the light is cut off from the film by the shutter except while the opening is passing the lens. The opening is adjustable.

Such a shutter usually is made of two half-disks mounted upon a shutter shaft; by setting these exactly over each other, the shutter will be "half open, half closed," or by adjusting them upon each other the open space may be reduced to any desired fraction of the "open" area. Some shutters are provided with adjustments whereby the shutter exposure may be changed while the camera is being turned. This is objectionable because it renders the shutter more liable to getting out of adjustment accidentally.

Exposure Time. The usual exposure is "three-eighths open." When taking pictures at the rate of fourteen per second, this figures out $\frac{3}{8}$ of 1/14 of a second, 1/37 second, or 27/1000 second, that the lens is open. The photographer experienced with shutter efficiencies in fixed camera work may note that this is an actinic value and not a mechanical value, and that the exposure mechanically is correspondingly of greater value than the figures seem to show.

One-thirty-seventh of a second actinic value is much more than the average of snap-shot hand camera exposures. It is a longer exposure than would be possible with the fixed camera for moving objects and longer than is customary with hand cameras. Moving objects will show a blur in the negative; when projected upon the picture screen, the blurred object of one image will fade into the same blurred object in a different position in the next image, and smooth motion will be simulated, the object becoming sharp again when its motion becomes slower.

Exposure Control. The time or length of exposure being fixed by the mechanical limitations of the art of the motion picture, and the negative film being of but one available speed or sensitiveness, the sole means remaining to the camera operator for adjusting his exposure value is the diaphragm stop. If the light is poor, the stop must be opened, and if the stop at its full does not give enough light, the picture cannot be made unless by "trick" processes. In the matter of limiting quantity of light, however, two elements come to the relief of the motographer. *First,* because the negative is to be used for printing a transparency, a negative may be of value which would be useless for opaque paper prints; and *second,* the motion in the projected film picture will keep the attention of the spectator on the high lights and cause him to overlook the lack of detail in the shadows. Successful motion pictures may be obtained from exposures so low in light value that nothing but failure could result with the fixed camera.

As the diaphragm stop is the only variable element available to the motographer, Table I has been prepared giving the proper diaphragm stop for each day and hour of the year, Eastman film (Watkins 250, Wynne 111), $\frac{3}{8}$ open, 14 pictures per second (1/37 second), latitude of the northern part of the United States:

TABLE I

Exposure Chart

	Jan.	Feb.	Mar.	Apr.	May June July	Aug.	Sep.	Oct.	Nov.	Dec.
5 A.M.	......	......	......	......	f.8	.....	.....	.....	.. ..	.....
6 A.M.	.....	......	f/8	f/11	f/16	f/11	f/8	......	......	......
7 A.M.	f/4	f/11	f/16	f/22	f/22	f/22	f/16	f/11	f/4	f/4
8 A.M.	f/11	f/16	f/22	f/22	f/22	f/22	f/22	f/16	f/11	f/11
9 A.M.	f/16	f/22	f/22	f/32	f/32	f/32	f/22	f/22	f/16	f/16
10 A.M. to 2 P.M.	f/22	f/32	f/32	f/45	f/45	f/45	f/32	f/32	f/22	f/22
3 P.M.	f/16	f/22	f/22	f/32	f/45	f/45	f/32	f/32	f/16	f/16
4 P.M.	f/11	f/16	f/22	f/22	f/32	f/32	f/22	f/16	f/11	f/11
5 P.M.	f/4	f/11	f/16	f/22	f/22	f/22	f/16	f/11	f/4	f/4
6 P.M.	......	......	f/8	f/11	f/16	f/11	f/8	......	......	......
7 P.M.	......	......	......	......	f/8	......	......	......	......	.....

This table is subject to all of the corrections given for the exposure table for the fixed camera. "Double exposure" for the motion-picture camera means only the next larger diaphragm stop, that is, the next lower number. "Four times exposure" means two numbers lower, and so on, each lower number doubling the exposure. "Half exposure" means the next stop number higher than the one given in the table. If a ray filter be used, the diaphragm stop must be opened to compensate, two stop numbers lower for a "four times" filter, one stop number lower for a "two times" filter, or three stop numbers lower for an "eight times" filter.

Eastman film is orthochromatic, and gives color values and cloud effects when used with an orange ray filter. It is of the sensitiveness used for "speed Kodaks," one and a half times as fast as ordinary Kodak film, and twice as fast as a Seeds 26x dry plate.

In addition to all of the corrections for clouds and nature of subject, as used for fixed photography, a quarter of the exposure may still be sufficient in view of the nature of the motion picture and the tendency of the spectator to view the high lights of the moving objects and neglect the shadows.

In computing an exposure, the object in motion is the center of interest, and all other parts of the picture are negligible. For instance, in a picture of an airship outlined against the sky, the sky correction (one-tenth exposure) is correct even though there are foreground objects; when the picture is projected, the spectators will look at the airship, not at the foreground. In a scene where one actor occupies the center of the stage and the play of expression in the face is the only action of the scene, it is poor motography to over-expose the white face for the sake of getting detail in the half-lighted studio background at which none of the audience is looking.

Exposure Meters. The exposure meter used for fixed-camera work is entirely suitable for motion-camera work, the speed of the motion-picture film being taken as 250 Watkins or 111 Wynne. Two further points must be borne in mind. *First,* that the 1/37 exposure given by the motion-picture camera with its 3/8-open shutter working at fourteen revolutions per second is full actinic value for the time, the equivalent of a focal plane shutter in a fixed camera, and much greater value than the similar schedule of the automatic leaf shutter common on fixed cameras. *Second,* that the motion-picture negative will stand an under-exposure of a quarter exposure or even less than that and yet give a successful print. To judge by the product of some studios and factories, the manufacturers prefer their films that way.

In using the Wynne meter, the light value or "actinometer time" is taken in seconds and the number of seconds thus found is set up opposite the plate speed number. The number representing the seconds of sun time is found upon the inner scale and the speed (111) of the motion film is found on the outer scale of the meter. These two are brought together. Now opposite the exposure to be given, read the diaphragm stop to be used. The exposure 1/37 is the line between 1/32 and 1/45. In the illustration, the sun time six seconds is set opposite the film speed 111, and opposite the 1/37 exposure line is read a diaphragm stop between *f*/7 and *f*/8.

In using the Watkins meter, the light time is taken in seconds and is set opposite the 1/37 exposure; opposite the film speed 250 then is read the diaphragm stop to be used. Thus, when a light time of 3 seconds is taken, 3 on the light scale is set between 1/32 and 1/45 on the outer ring which is both exposure and plate speed scale. Opposite 1/250 will be read either U. S. No. 8 or $f/11$.

In using any meter in the field, the correction for the nature of the subject, and for the allowable or desirable under-exposure of the film, is always to be made. If the camera man should find that his critics or "bosses," whosoever they may be, prefer thin negatives resulting from under-exposures, the film speed may be taken as Wynne 256 or Wynne 512 and the meter scale will give directly in its scale reading the required diaphragm stop with the correction for under-exposure—as compared with fixed camera work—as desired.

In the daylight studio, the meter will show the value of the daylight upon the scene set, and will give the stop required. If the stop required is larger than can be had in the lens, the meter will show by a proper interpretation what proportion of the necessary light is had, and the remaining proportion of light may be supplied by lighting a partial battery of lamps.

In the artificially lighted studio scene, the exposure is constant and is known from experience, being always the same, day or night, scene after scene.

The exposure value for a scene lighted with standard Cooper-Hewitt mercury-vapor lamps rated at 700 candle-power may be calculated according to the following formula:

Take the average distance from all lamps to waist height of an actor standing in the middle of the scene set, measured in number of feet. Multiply this number by itself, divide by ten times the number of lamps, and the quotient is the correct exposure at $f/16$. Thus, with 100 lamps averaging 10 feet from the middle of the stage setting, the solution is $10 \times 10 \div (10 \times 100) = 1/10$ second at $f/16$, or 1/40 second at $f/8$. Therefore, for such a setting, stop $f/8$ should be used.

Where the light is insufficient, it is possible to open the shutter of the camera to ½-open-½-closed, thus increasing the exposure by one-third of its light value. By turning the camera slowly, the exposure value is further increased, but this can be done only with the result of speeding up the resulting action when the print is projected. It is the producer's option, not the camera man's.

Panoramic views of poorly lighted scenes without moving figures, as the interior of churches, court yards, statuary, conservatories, etc., and factories with the machinery motionless, may be made by lengthening the exposure by turning slowly, but only by the most skilful actors is it possible to put any lifelike movement into such a picture.

Duplicate Exposures. Exposure values are always doubtful even when calculated from the meter. When two cameras are working side by side to make duplicate negatives of the same scene, it is well to have the diphragm stop of one camera one number or even two numbers above the other, giving the developing room a better chance to get one really perfect negative out of the pair of films. Duplicate exposures upon a scene are made for several reasons:

That one negative may be held in reserve in case of accident in a printing machine or elsewhere.

That two exposures may be available in case of accident before or during development.

That one negative may be exported for printing abroad.

That two films may be exposed as assurance against accident in one of the cameras.

That cameras of different makes may have their products confused.

Trick Crank. The main crank gives a large number of pictures per second, and the camera operator acquires a skill in turning it which enables him to take fourteen pictures per second with great precision. When it is desired, for trick picture purposes, to take the pictures at a slow speed—that the action may be speeded up in projection—it is possible to turn the main crank at half speed, but better to use a "trick" crank, which the camera man may turn at his normal accustomed speed. This trick crank is geared down in the camera and gives only half the inside speed, or less, sometimes making only one picture per turn of the crank. The opening in the shutter must be changed accordingly, half the opening for half the picture taking speed, in order that the exposure time of 1/37 second may be maintained. Correction by the diaphragm is possible, but results in too much motion in the object if rapidly moving. Where the main crank is detachable, it may be put on either the main shatf or the trick shaft of the camera.

SCENE FROM PHOTOPLAY, "THE ROSE OF OLD ST. AUGUSTINE," OR "A TALE OF JEAN LAFITTE, THE PRIVATEER".
Courtesy of *Selig Polyscope Co., Inc., Chicago*

THE POPULACE PREPARING FOR THE REVOLUTION IN PARIS
Scene from the Vitagraph Life Portrayal of "A Tale of Two Cities"
Courtesy of the *Vitagraph Company of America*

Reversing. The camera may reverse the action in three methods, of which the third mentioned is the usual one employed. *First,* some cameras are so constructed that the handle may be turned backward or forward. When making reversed scene with such a camera, load the film into the take-up position and the take-up box into the feed position, then change the take-up belt or gears to wind upon the feed spindle position which now is reversing take-up. *Second,* mount a reversing prism in front of the camera and turn as usual. *Third,* the camera is provided with a tripod screw or socket in the top. Turn the camera top down on the tripod, and turn as usual except that the crank now is upon the opposite side of the camera from that to which the operator is accustomed.

Finders. A finder for focusing is not convenient for determining the view while panoraming. It is possible to panoram accurately by sighting along the side or top corner of the camera, particularly when two operators are working the camera, but when there is but one and he stands at the side of the camera, turning two cranks at the same time, a finder bringing the view into convenient position will be an advantage.

Indicator. A film-measuring device works upon the constant feed of the film and has its dial outside. The indicator can be reset by the operator. The operator sets the hand to zero when loading the camera, and the hand then will read upon the scale the length of film turned through. Knowing the length put into the camera when loading, the operator can by subtraction know the length still remaining. When not enough film remains for the next scene, the camera must be reloaded, the lens being capped and the film "marked," and the remainder of the film wound through into the take-up box before opening the camera to reload.

It is possible to make the dial of the film indicator read "remaining film" instead of "used film," the operator setting the hand backward to the equivalent of the film length when loading the camera, and the hand reading upon the dial at all times just the amount of film remaining as the hand approaches zero.

Marker. The marker is a push button or pull knob on the outside of the camera, and usually operated to punch a hole in the film near the film window. Its use is to indicate on the film the end of a scene. For the benefit of the developing room, a "test exposure" of a few feet of film is made before beginning the taking of the scene for the final motion picture negative. The camera is set up, focused, and closed ready for use, the light-struck leader is turned off into the take-up box, and then several turns of the crank are given, exposing a dozen feet of the film before the action is ready to begin. The "marker" then is operated to punch a hole in the film, or two or three holes with single picture space between them. The scene then is taken. In the developing room, the leader of film ahead of the marker holes may be cut off and developed to learn whether the exposure is correctly timed, and whether regular or special developer shall be used in the development of the scene of the film.

When the unused film in the camera is not enough to cover the length of scene which the producer is about to enact before the camera, the marker is operated again and the remainder of the film wound through. A memorandum of the number of feet of unexposed film is sent with the reel when it goes back to the factory, that length is measured off and the film is cut at the marker holes, thus saving the unused film.

Bianchi Camera. This camera does not use the intermittent motion, but uses a continuously moving film and passes the rays of the image through a revolving prism. The only difference to the camera operator is the method of threading up the film.

Hamacek Camera. This camera uses no sprockets, and the film is not perforated. The method of use is in all ways similar to the camera using perforated film, except in the detail of threading.

No matter what the mechanism of the camera, the operator should understand it thoroughly, and keep it clean, properly oiled, and in perfect adjustment and running condition.

Factory Floor Plan. Fig. 15 shows a floor plan suitable for a small motion-picture film factory. This shows only the "photographer's" department, the sales offices and the studio being adjacent or elsewhere.

The plan is self-explanatory outside of the developing room and the light-trap entrance to the developing and printing rooms. The perforating room is entered only through the printing room. Partitions form a tortuous pathway into the developing room and printing room from the shipping room, permitting the free access to and from these rooms without doors, and without danger of accidental light flashes into the rooms by reason of the opening of the doors. At the end of the developing room next the washing room a large door shown double is of sufficient size to permit a developing cage to pass through. Because of the opening of this outer door to the developing room, there is no door between the printing room and developing room, passage being had through the entrance passageways, or by a turntable in the partition.

Development of Films. *Cages.* For development, the exposed or printed film is wound spirally upon cages 3 feet in diameter and 5 feet long, one such cage taking a 200-foot roll of film. The ends

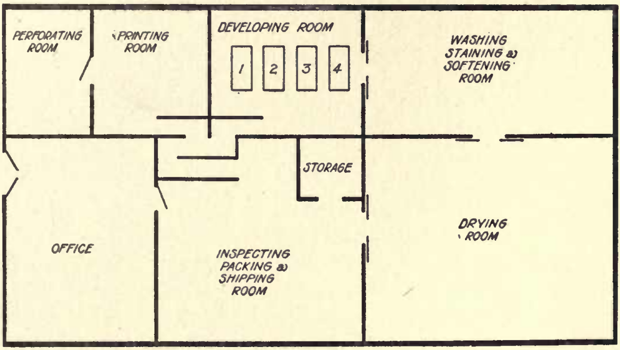


Fig. 15. A Film Factory Floor Plan

of the cage are built like wheels of fellies and spokes, the ends being connected by round polished wood rods, the whole appearing like a large cylindrical cage with an axle through the center.

Trays. The developing tray is of wood, 6 inches deep, and has within it a zinc trough curved with the curvature of the developing cage. Standards at the ends of the developing tray take the axles of the developing cage and support its surface within ½ inch of the bottom of the zinc tray which it fits closely but does not touch, turning freely on its axle. A few gallons of developer in the zinc tray will develop several cages of film, the cage being turned constantly during development. The wood tray catches what developer splashes over the zinc.

Trays for washing do not have the inner zinc trough, being filled with water, running water if convenient. The hypo trays also should have an abundance of hypo solution, and do not require the inner zinc trough for economy of solution as is the case with the developer.

Room. Four trays are shown in the floor plan, No. 1 developer, No. 2 water, No. 3 water, and No. 4 hypo fixing bath. The cages are handled by the developing room operator and an assistant, lifting at the two ends of the axle. The routine of development is as follows:

Developing. Through the large door, a developing cage is brought in and hung over the developing tray on high journals, a few inches above the developer. The large door being securely closed and the room lighted by red light only, the operator opens a tin box of exposed film, attaches one end with a clamp to one of the slats of the cage, at one end; the assistant turns the cage and the operator feeds the film on from the roll, attaching the end when all is fed on. The cage now is set down on lower journals and turned in the developer by the assistant while the operator watches the images until fully developed. The cage then is lifted to the wash water tray, turned a few times, then to the second wash water and turned a few times, then to the fixing bath. When the milkiness is gone, the big door is opened, the cage with the wet film is carried out to the washing room, and another empty cage is brought in and the big door closed again.

Washing. Two assistants in the washing room wash the film through several waters or in running water to free it from hypo, then turn it in a tray of diluted glycerine—1 part glycerine, 33 parts water—for a minute and carry it into the drying room.

Drying. The drying drums differ from the developing drums in having smooth surfaces instead of being cylinders of slats. Also, they may be larger than the developing cages, since they do not have to be handled—4 feet in diameter by 8 feet long is reasonable, and will hold 600 feet of film. Two attendants are required in the drying room. The end of the film is attached to the drum with a thumb tack and one attendant turns the drum by hand, while the other attendant guides the wet film from the developing cage to the surface of the drying drum. When the end is reached, it is attached with a tack or push pin, and the drying drum is belted to a motor which drives it continuously until the film is dry. The developing drum is sent back to the washing room for use again in the development of films.

When films are dry, they are unwound from the drying drums to reels or into baskets and taken to the inspection room, if positives, for shipment, or sent to the photographer for inspection and proofs, if negatives.

Making Titles. The making of a title is a simple case of the making of a motion picture of an object which as a general rule is not moving. The titles are set up and properly lighted and photographed with a motion-picture camera, using the length of film called for by the synopsis. Most conveniently, titles are prepared in batches, a number of titles being photographed upon a long strip of film which then is developed in the usual way and a proof print taken. The titles then are cut apart and spliced into the motion scenes as required for the complete film pictures.

To make titles with movable letters, a table top is covered with black cloth and a motion-picture camera is permanently mounted above it and focused upon the surface of the table. Lamps are placed around the table for lighting the title. The light need not be excessively bright, as the camera may be turned slowly and with a large shutter opening.

Upon the table top, white letters are arranged to form a title, the title is photographed by turning the camera above the table, and the letters immediately are arranged again for the next title. Letters cut by dies from white paper may be bought in various sizes, or porcelain letters, such as are used for signs on window glass, also are obtainable in various sizes and in various styles of lettering. Lines upon the table top show the edges of the field of the camera and within the lines the desired title is formed, arranging the letters of each line against a straight edge which is removed before photographing.

The table top is a convenient means for copying all kinds of titles, merely laying the title upon the table, if the suspended camera is arranged so that it can be moved to different heights to provide for different enlargements of the various titles, and further arranged so that it can be focused conveniently.

In photographing either a yellow telegraph blank printed with black ink or a white telegraph blank printed with blue ink, a heavy yellow ray filter should be used over the lens to increase the contrast in the resultant title.

A suggestion for the photographing of titles is that a slow film be used for the negative instead of the extremely fast sensitive film used for the motion scenes, since a slow film will give a greater contrast in the resulting titles.

A reversed title is made as follows: With a title in black letters on a white card, photograph the title and develop as usual; this negative has clear letters on a dense background. Make a reversed print by printing with the celluloid side of the negative against the gelatine side of the printing stock. This print when examined will have its letters reading backward, like a negative, but will have black letters on a clear background. This reversed print is the reversed negative, to be spliced in with the negatives of the motion scenes for printing the titles for the finished pictures, the printing for the final scenes being gelatine to gelatine, as for the motion scenes. In the print, the reversed title will appear with clear letters upon a dense background, making the title when projected show white letters upon a black screen.

Printing. *Room.* The proper location for the printing room is between the perforating room and the developing room, as shown in the floor plan of Fig. 15, with entrances into both perforating and developing rooms as conveniently arranged as possible. The printing room constantly requires supplies of perforated film from the perforating room, and constantly supplies the developing room with printed film for development. The connection between the printing room and the developing room is particularly close, since by immediate development of the film after printing the developing room operator may be able to note errors in printing which might spoil large quantities of film if printed far in advance of development. The printing room is provided with printing machines and power to drive them.

Machines. Obviously, a negative for a reel of film 1,000 feet long cannot well be handled in a contact printing frame such as is used for printing the negatives from a fixed camera, nor is it practicable to cut the negative into sufficiently short lengths for such contact printing even if proper results could be obtained in that manner. Since the standard roll of film furnished by the makers of the raw film is 200 feet, and since the developing cages are also of a size to handle the 200-foot rolls of film, the 1,000-foot negative is cut into five pieces of 200 feet each and the 200-foot length is the standard length through the factory up to the time for splicing together into the reel for shipment to the film exchange.

The printing machines are of two types, stepping and rotary. The *stepping printing machine* has a film window and an intermittent film movement. There is no lens. An incandescent lamp is arranged to shine upon the film window, being adjustable in distance from the window. The lamp is enclosed, to prevent leakage of white light into the printing room, and the film window is backed with ruby glass to permit the operator to see the image in the window and to prevent leakage of white light. A framing device is a desirable feature of a stepping printing machine, and a necessity if the intermittent film movement is not entirely reliable. A projecting motion head may be used as a printing machine, or in the case of amateur work the lens may be removed from the camera and the camera may be used as a stepping printing machine. The projecting head has the framing device, while the camera has not, and either requires the printing lamp with its adjustment for distance to be added, after removing the lens.

Two feed reels are provided, one for the negative and one for the raw positive film stock, the two ends being started through the film window together, film sides together and the negative next the light, so the light shines through the negative upon the positive. The shutter remains upon the machine. The operator then applies the power and keeps the image framed in the film window. A take-up reel rolls up the printed positive film, but it is customary to run the negative into an open basket and to rewind it before making the next print, so that the printing always proceeds from the same end of the negative. The stepping machine will print from 10 to 100 feet per minute.

The *continuous printing machine* is much faster in operation than the stepping machine, printing from 40 to 500 feet per minute according to the quality of the negative, but the greater perfection in mechanism required renders the continuous machine difficult to construct, and the greater accuracy required in adjustment and operation sometimes results in losses of film not encountered with the stepping machines; and if the defective film be not discovered and discarded, then the manufacturer is giving to his customers an inferior product, which is the worst condition of all.

In the continuous machine, the two films, negative and positive, are wound with a steady motion from the feed rolls to the take-up rolls, passing together in contact in front of a window lighted with the printing lamp. This sounds very easy, but the slightest slipping of one film upon the other will produce an effect upon the picture screen when projected which will drive a spectator to insanity, and the slightest lack of registration in the perforations of the two films will produce the undesirable slipping.

Exposure. By the term "exposure" in printing, the same meaning is conveyed as in using the camera, namely, the amount of light which is permitted to pass to the sensitive film. In the printing machine this depends upon the intensity of the printing light in the window, the size of the window or shutter opening, and the speed at which the printing machine is driven.

With either the stepping or continuous machine, the amount of exposure may be regulated without stopping the machine by changing the distance of the printing lamp from the film; doubling the distance cuts the exposure value by four; and dividing the printing-lamp distance by three, multiplies the exposure value by nine, according to the law of squares.

With either the stepping or continuous machine, the amount of exposure may be regulated by changing the speed of driving the machine. This regulation does not apply the law of squares but gives a lineal inverse ratio to the exposure, half the speed giving double the exposure, double the speed giving half the exposure, and so on.

With the stepping machine, the opening of the shutter may be changed from ½-open to ¼-open or ¾-open, the change in exposure value being in direct ratio to the size of the open portion of the shutter. It is possible to construct printing machines in which the shutter opening may be changed without stopping the machine, inasmuch as some motion-picture cameras have this feature in the shutter and such a camera shutter may be used in a stepping printing machine.

With the continuous machine, the size of the film window or slit of light shining upon the film may be changed without stopping the printing machine. The printing window or spot of light which impresses the image upon the positive film as the two films pass may be large enough to cover a full image, or two images, or may be only a quarter of an inch in width, or even narrower, extending always from side to side of the film. The narrower this band of light, the less injurious to the resulting print will be any lack of accuracy in the adjustment of the printing machine, or in the perforations of the two films. With a narrow band of light, the printing lamp must be nearer, or brighter, or the speed of the machine must be slower.

Incandescent electric lamps are used because of the uniformity of their illuminating power.

Film Adjustment During Printing. The 200-foot piece of negative is composed likely of half a dozen motion scenes, some inside studio work and some outdoor work, interspersed with titles. That all these short negatives, made under varying conditions, should have the same printing density and require the same exposure in the printing machine is quite unlikely. Each 200-foot length of negative is inspected by the chief photographer and ticketed for exposure. Following is a sample exposure ticket for a stepping printing machine having lamp distance as its only adjustment while moving.

First Negative, "The New Boarder"
Speed 25 feet per minute
Shutter ¾-open
12′ title 3″
30′ interior scene 10″
6′ title 3″
20′ interior scene 10″
10′ outside scene 8″
60′ interior scene 10″
6′ title 3″
40′ outside scene 6″

The number of feet given at the beginning of each line of the ticket indicates the length of film which is taken up with the title or scene, that the printer may anticipate the instant when the next change is to be made. The exact instant is known in a stepping machine by watching the images of the negative in the film window. In a continuous printing machine, the images are blurred by the steady motion, but the change in density of the negative will be noticed, and further guidance may be had by cutting a small notch in the edge of the negative film and arranging an electric circuit to tap a bell as the notch passes.

The lamp of the printing machine is movable by a lever which is provided with pointer and scale and with movable stops which may be set to stop the lever at different lamp distances. To print the negative ticketed according to the specimen ticket given, the printer sets stops permanently at 3″ and 10″, the limiting positions, holding the lever against the stops for that portion of the negative for which those stops are correct, and holding the pointer on the scale at the proper number for other sections of the negative.

For use with a continuous machine, the exposure ticket would give at the head the film speed and slot width, or would give at the head the speed and lamp distance and then give the slot width for each portion of the negative, the adjustment being made by slot width rather than by lamp distance.

Making the Exposure Ticket. By experience, the photographer in charge can judge the printing exposure required by looking through the negative, or comparing it with standard specimens. The first print should be developed promptly and inspected, the ticket being changed if required. In case of doubt before printing, the negative may be run through the printing machine under known conditions with a foot of positive film, this foot being attached to the developing drum with tacks while a roll is being developed. By the resulting specimen print, the proper exposure may be judged.

Developing Prints. Processes suitable for developing lantern slide plates in fixed camera photography are suitable for the motion-picture positive prints. Hydro-metol or hydro-quinone developer are usual. The positive print is developed, washed, fixed, washed, softened in glycerine, and dried.

Inspection. After drying, the prints are carefully looked over, foot by foot, for defects of any character whatever. The five 200-foot pieces of each 1,000-foot reel then are spliced together in proper order and the reel is ready for packing and shipment. Isolated defective images are cut out and a splice made. Where more than a limited number of images in one place are found defective in the print, the place is marked and a short length printed from the negative and substituted for the defective length of film. Hand staining, hand coloring, and hand spotting of the prints are done in the inspection department unless of such quantity that a special department is created for the work. After passing the inspection, the film is packed in its sheet iron shipping cases, one reel in a case, and sent to the storage room until required for shipment.

Print Spotting. Very little hand work is done upon the print after it is dried, but sometimes a reel of negative will have a scene which requires hand work on each print to bring it up to the standard of the factory, or to make it passable at all. If the scene cannot be retaken to secure an improved negative, the hand work upon the prints must be done. In many instances, it is possible to balance the cost and inconvenience of necessary hand work upon prints or negative against the cost of reproducing the scene and securing an improved negative.

Staining. Staining of a print is done in the wash-room as a part of the washing process, and is done in the same manner that a laundress uses in bluing her clothes. The last rinse water, or the glycerine bath, or both, are charged with an aniline dye or other water-soluble dye stuff, and the film takes the color in passing through the baths. This produces a stained gelatine film on which the silver image is still black. When projected it produces a black picture upon a tinted screen. It is largely used for reversed titles, producing the title in tinted letters upon a black picture screen and giving a more pleasing effect than a plain white title. The Western Union Telegraph Company uses a yellow telegraph blank, and titles showing such messages sometimes are stained yellow to lend realism to the title.

Toning or Monochroming. In the toned or monochromed film, the gelatine remains clear and the shadows of the image are colored, giving the effect upon the picture screen when projected of a picture painted with color upon a white sheet. The processes may be classified as those which obtain the colored image in the first development of the positive film and those which obtain the color by subsequent manipulation.

With hydro-metol or hydro-quinone developer having no bromide or insufficient bromide, the image will come up in olive green. Because of the absence of bromide, the development is very rapid and difficult to control, and the printing exposure must be correspondingly short to secure a good print. With a proper adjustment of printing exposure, developer strength and bromide, neutral blacks can be secured. With a developer rich in bromide, development is slower and the resulting film shows shadows tending toward brown, and with still more bromide the print shows purple or even red. Printing exposure must be increased to avoid unduly prolonged development. With a printing exposure of ten times normal for black and a development period of ten times normal for black and with sufficient bromide in the developer to restrain the development to that period of time after that exposure, the resulting images will be a purple which tends toward red. Monochroming of this class is done in the developing room, before the print is passed out to the daylight washing room.

Processes in which the colored image is not obtained in the first development may be carried on in the daylight washing room, before the film is bathed in the glycerine bath. Re-developing for sepia, and intensification and toning for blue, green, and red may be done as for lantern-slide plates. The literature of the photographic art is amply provided with formulas for these processes.

Repeater Printing. Where it is desired to give a special tone to a single scene or short portion of a complete film picture, the negative for that scene may be omitted from the complete negative, a few inches of blank film or special code film being inserted instead. The short scene now is placed in the printing machine and the two ends stuck together, forming a belt. A 200-foot roll of positive film is started through the printing machine, and the belt of negative is printed repeatedly for the entire length of the positive roll, if required, or for as many rolls as are required. A large number of repetitions of a short scene thus may be developed and toned at once, being cut apart after drying and spliced into the regular prints at the proper place, the bit of dummy film put into the negative acting as a guide to the inspection room to put the special scene in its proper place.

Hand Staining. Titles or short scenes forming parts of long pictures and requiring staining may be done more conveniently by staining each positive print with a brush, by hand, than by special work in the developing or washing room and the subsequent splicing required in the inspecting room. One of the desirable features of hand-staining is that there is no danger of errors in the order of scenes in splicing up, since the splicing is avoided. The slight unevenness of hand-staining is entirely negligible in reversed titles. Hand-staining is done in the inspection room after the film has been dried.

Coloring Films. *Hand Process.* The primitive method is to take the positive film and a set of brushes and water colors and color each of the small images as though they were so many separate and distinct photographs, as indeed they are. In connection with this method of hand-coloring the intermittent mechanism of the camera or projecting machine may be used with great convenience. The strip of film to be colored is arranged over a glass plate through which the light may pass, since the colorist should look through the film to get the effect of the color. A leader is spliced (or pinned) to the film to be colored and is taken through an intermittent movement controlled by the colorist's foot upon a pedal, that by a single pressure upon the pedal the film being colored may be stepped forward one picture. This change will take place very quickly, so that the colorist seems to be working upon the same image. Taking the blue color for the sky, the colorist colors the sky of the first image, lifts the brush, and presses the shift pedal, proceeding to color the sky of the next image without lifting the hand from the position of applying the color, merely lifting the brush from the film while shifting the images. Having colored all the skies, a certain tree, house, or chimney is colored throughout the length of the scene; then the moving figures are colored, the brush of the colorist following the figure over the small picture as the figure moves in the action of the play. Taken in connection with the pedal shift, the coloring of some film scenes becomes surprisingly rapid. Hand-colored scenes are spliced up with monochromed and stained scenes and titles. A "full hand-colored film" picture has been reported by colorists as requiring a day's labor of a worker for each 35 feet of film. The time for different scenes will vary widely, and this 35 feet per day may be taken as a maximum of labor in hand-coloring.

Stencil Process. A stencil is made for each color to be applied to the film, and the proper colors are applied through the stencils with brushes operated by hand. Assuming that it is decided to color a scene with three colors, red, yellow, and blue: Four prints of the scene are taken by the colorist; upon one is painted with red all of the parts of each image which are to be colored red in the finished colored picture, just as the hand colorist would finish with the red before taking up another color. The colorist next takes the yellow, but takes also the second of the prints and colors upon the second print all of the parts which are to be colored yellow in the finished picture. The blue color and the third of the prints now are taken and all parts to be blue in the finished picture are colored blue in the third film print. By looking through all three of the prints together, the colorist may judge what the result of the combination of colors upon one print will be, and may change any of the prints. When finished, there are three colored prints, each of which bears but a single color. If more than three colors had been decided upon there would be more than three of the partly colored prints. The three prints now are cut with a sharp knife or with stenciling chisels, removing all of the colored portions and leaving all of the uncolored portions. The result is a set of stencils, in one of which every red spot on the finished colored motion film is indicated by a hole in the stencil, in another of which the yellow is represented similarly by holes, and in the third of which the blue is represented by holes.

The fourth print of the scene is taken, the red stencil is placed upon it and a brush charged with red ink is run over the stencil. The yellow stencil then is placed upon it after removing the red stencil and a brush charged with yellow ink is run over it. The yellow stencil being removed, the blue stencil is placed upon the film and a brush charged with blue ink is run over it. The result is a tri-color print with the colors stenciled upon the black lines of the photographic print. A monochromed or stained print may be stenciled over in the same way, producing desired effects.

Machine Process. The machine feature consists of the application of the ink through the stencil by a stenciling machine. An illustration from the published American patent of a French film coloring machine is reproduced in Fig. 16. The method of making the stencil is the same as for a hand-stenciled film. The operation is as follows: Having the stencil for one color, and the film to be colored, each in a roll, the roll of stencil is placed in the machine at *23* and the roll of film to be colored is placed at *24*. The ends then are taken through the guide blocks *25*, the stencil band being shown by the dotted line *2* and the film to be colored being shown by the solid line *3*. These are passed together over the large roller or drum *1*. Just above this drum there is a short endless band of ribbon *21*. This, the inventor tells us, should be of velvet, so that it offers a soft brushlike surface which is well suited to pass through the holes in the stencil band and touch the film to be colored, which lies just underneath. The band *21*, which is really an ink brush, runs over three rollers, and runs in a direction opposite to the direction of the film and stencil band, the directions of the movements of the parts being shown by the arrows close to the different bands; thus there is a considerable brushing effect between the inking band and

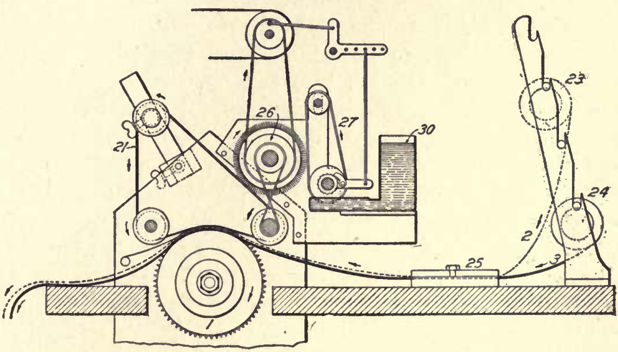


Fig. 16. Film-Coloring Machine

the film to be colored wherever a hole in the stencil band permits the brush band *21* to get through to touch the film. This charges the film with ink or dye, coloring it in every spot where the color is desired, that is to say, everywhere that a hole has been made in making the stencil band *2*.

The supply of ink is taken from the tank *30* and is carried first upon a short belt *27;* it is taken from the belt *27* and put upon the inking ribbon *21* by the revolving brush *26*. The whole device is driven by a belt and runs continuously, the teeth upon the drum *1* keeping the stencil band and the film to be colored traveling constantly at the same speed, and keeping them always in register.

As in hand stenciling, a separate stencil is required for each color, and the film to be colored is run through as many coloring machines, each having a different stencil and a different color of ink, as there are colors in the finished picture.

Waterproofing. The picture film is celluloid upon one side, gelatine upon the other. The celluloid side is hard, glossy, water-resisting, scratch-resisting, dust-resisting, but the gelatine side is easily scratched, collects dust in the scratches and sometimes without them, and is ruined by a drop of water, yet requires a moist atmosphere or it will crack by becoming too dry and brittle. In the process called "waterproofing" celluloid or a similar substance in solution is applied over the gelatine film, strikes through the film and unites with the celluloid body, forming a celluloid skin over the delicate film and imprisoning the gelatine like the ham in a railroad sandwich. After that treatment, both sides of the picture film are hard and scratch-resisting, and the film may be washed with water (by special machinery for the purpose) to remove dirt. At the same time, the moisture which made the film flexible is imprisoned with the gelatine and the film remains flexible. The process is patented. Either plain or colored films may be waterproofed, or the negatives in the printing room. The proper time for waterproofing is before the film is shipped for use.

Packing Films for Shipment. The films are shipped in full reels, or 1,000-foot lengths, wound with open center with the title end out. Each reel is packed in a circular, flat sheet-iron can and then in a wood box; this is a requirement of the express companies. A further requirement is regarding a danger label, which must be printed on red paper not less than 3 inches square, reading as follows: "*Moving picture films must not be loaded or stored near a radiator, stove, or other source of heat.*" The reason for the last rule is that celluloid when warm gives off explosive vapors.

Reclaiming Waste. Light-struck films develop black, and these may be sold to film exchanges for leaders. The punchings from the perforating room contain silver, and this may be reclaimed at a profit by a chemical process. The black silver in junk or spoiled film may be reclaimed but usually is not, and the same is true of the silver in the used hypo bath.

MARY IS BROUGHT BEFORE THE CHIEF
Scene from Photoplay, "Mary's Stratagem"
Courtesy of *G. Melies Company, New York*

SCENE FROM PHOTOPLAY, "THE INHERITANCE"
Courtesy of *Thomas A. Edison, Inc., Orange, N. J.*

PHOTOGRAPHIC EQUIPMENT

All supplies needed by the manufacturer, other than cameras, printing machines, perforating machines, and film stock, may be bought in any city in the open market.

Buying Cameras. Urban and other English and French cameras may be purchased and imported into the United States at costs ranging from $300 to $400; printing machines cost about the same prices as cameras, for either the stepping or continuous movement. The importation or manufacture of cameras in the United States is influenced by the patent situation. Cameras have been offered for sale in the United States at prices quoted from $475 to $2,500.

Making Cameras. A projecting machine may be converted into a camera, though rather bulky for field work and requiring some ingenuity to accomplish all the desired features of a camera for both studio and field work. A projecting machine with lens removed and a hooded lamp at the aperture becomes a printing machine almost without change. The pin or claw intermittent movement is preferable to the sprocket for cameras.

Buying Films. Several prominent makers of roll films for hand cameras have taken up the manufacture of film for motion-picture cameras and are supplying the market. The price charged is about four cents per foot, unperforated. From some dealers it may be bought perforated.

Fire Risk in Storing Films. A rolled film in its tin box is a perfectly safe proposition at ordinary temperatures. The celluloid body of the film, whether raw film, prints, or junk, gives off an inflammable and explosive gas, giving it off more rapidly when warm than when cold. A vault for storing films must have a vent; a slow but continuous draught of air through the vault seems a logical provision for safety.

CHRONOPHOTOGRAPHY

The requirement for scientific study usually is a clear sharp picture taken at regular intervals. The intervals may be short or long, either at the rate of several hundred pictures per second or at the rate of one picture per hour, or one per day. The results occasionally are of interest to the general public.

Motographic Microscopy. The image of the thing to be motographed is taken through microscopic lenses to the motion camera in a manner easily accomplished when the lenses are available. The greatest difficulty is found in illuminating the subject sufficiently to achieve the short motographic exposure without destroying the subject by the heat of the source of light. By carrying the light through water or an alum cell before it reaches the subject, and by operating a shutter between the light and the subject so that the light is cut off from the subject except while the exposure is being made, such relief from the heat may be attained as will permit making a motographic picture without destroying the thing motographed.

Motographic Ultramicroscopy. Ultramicroscopy is the name given to the process of microscopic study which makes use of the ultra-violet (invisible) rays, recording the image upon a photographic plate and studying it after development. Motographic film has been operated successfully with this class of microscopic study.

X-Ray Motography. The invisible X-ray penetrates many solids which are impenetrable by light, and the X-ray is able to influence the photographic dry plate or motographic film. Passing through the body, the X-ray is obstructed by the bones and the heavier and denser organs, throwing a shadow of them upon the photographic surface. By arranging the motographic camera with proper shutter and protective X-opaque shields for the reels and film, motion pictures of the heart in action, of circulation of the blood, etc., are possible.

TRICK PICTURES

There is no standard "box of tricks" beyond which lies nothing of interest. The interest never ceases when trick-picture making has been begun. This subject was opened under the discussion of tricks in the production of the specimen film, "High-Jumping Johnnie." The thoughts there given were but the simplest of tricks, easily understood or almost guessed by the audience in watching the picture. In addition to the tricks used so much that they may be considered standard illusions in motography, special effects may be attained by tricks as subtle as those of the accomplished magician before his audience. A few of the standard tricks of illusion are here described.

Reversals. The method is to show upon the screen the series in the order just reversing the order in which the pictures were taken. When this is done, all the characters would walk backward, objects would fall from the floor upward to the shelves and table, smoke would float down into the chimney, etc.

Means. Turn the camera bottom up on the tripod—by a tripod socket in the top of the box—this will reverse the action. Or print by a special printing machine which steps the film negative in one direction and the positive stock in the other direction.

Effects. A runaway horse may run backward and push the wagon before him just as easily as running forward if there are no people on the street who also would walk backward and thus reverse the illusion.

A witch desires to create money from a piece of tallow candle. She melts the candle and pours it on a surface to cool. From this point a picture of coin casts in tallow melting on the same surface is inserted reversed, giving the appearance that the melted tallow magically takes the form of coins and hardens. The witch then apparently picks them off as good coins magically created.

A sculptor makes a wonderful statue in record time, with a wealth of detail, by skilfully pulling apart a clay model before the camera, the film then being run reversed whereby he seems to build up, not to tear down.

A swimmer, having jumped into the water, by a reversed film jumps just as easily out again, landing safely upon the bank, pier, or springboard, feet first, every time.

Speed Pictures. When pictures are taken slowly and projected at the standard rate, the action of the picture seems correspondingly faster.

Means. Reduce the shutter opening and turn the handle slowly, or turn the camera mechanism, by a specially provided gear to a special handle or shaft called the "trick handle."

Effects. Chases may be made to appear much more rapid than they really are, and acrobatic actions on the part of a comedian in the scene may be made so violent as to be ludicrous. The ordinary traffic of a street may be thus speeded up.

Dummies. When a character is required by the plot of the picture to pass through some hazardous experience, such as having his head cut off or falling from a high building, a dummy is substituted.

Means. The action having progressed to the point where the substitution of the dummy is necessary or convenient, the producer cries "Hold it," or "Freeze," and all actors instantly become motionless and remain so, the camera man stops turning, the actor to be *dummied* gets off the scene, the producer and his assistants arrange the dummy figure where the actor was, the camera man is given the signal to turn, the remaining actors are given the signal to go on with the action until it is required to replace the dummy with the actor, when the same plan of freezing over the change is carried on. When the film is developed a short length may be cut out at each of the freezes if need be to improve the picture.

Effects. An accident frequently is a part of the plot of the picture. The dummy substitute may be used to relieve the actor from danger in that scene. The film picture story says that the hero rushes to the rail of an ocean liner in mid-ocean, hurls himself overboard and swims to shore. The picture is made by his rushing to the rail, picking up a dummy of himself and throwing it overboard, while the photographer or producer cuts out that part of the film where he picks up the dummy and lifts it above the rail. The swim to shore and the landing on the distant beach is made in the tank in the studio backyard.

Ghosts. Apparitions are made by exposing the negative film twice before developing it.

Means. A lens with an iris diaphragm so that it may be opened and closed gradually while the camera is running. The full picture having been made, the ghost is staged upon a stage set all in black and the film already exposed is run through the camera again as noted in advance, so many feet with the lens closed, then gradually opening the diaphragm to about one-tenth of a normal exposure continuing for so many feet and gradually closing if the ghost is to fade away, but suddenly capping the lens if the ghost is to vanish instantaneously.

Effects. Only white or light figures may be brought into the picture in this way. The good white fairy may appear thus to wave a signal to the favored hero. A fairy symbol may appear upon the wall of the room and disappear. The actor may lie down to sleep and upon a blank wall (left blank for the purpose in the scene setting) appears the action of his dream.

When the actor thus appearing under the ghost effect is required to take an active part in the play subsequently, or when the figure thus to be produced is not white or substantially so, then the illusion may be made under the plan for dissolving views.

Dissolving Views. When it is desired to have an actor appear in magical manner slowly and to take a part in the action thereafter, the producer causes the actors to freeze, and the camera man reduces his aperture gradually to a closed shutter. The camera man turns his camera back to the point where he began to close, the actor to be produced takes his position and the camera man begins to turn and gradually opens his shutter diaphragm; when the diaphragm is nearly open the action may proceed. Much practice on the part of the camera man, or a special camera with automatic diaphragm is required. Disappearance of any character is effected in the same manner.

Double Printing. Apparitions may be produced by making the two exposures upon separate films and running the two negatives through the printing machine together with the printing stock, so that the images of both the negatives are impressed upon the sensitive print stock.

Where the object to be added to the scene is a dark object to be added in a light area of the original scene, it is added by running the printing stock through the printing machine with the first negative and again with the second negative, separately.

When a satisfactory print has been produced by the double printing process, the print is copied upon another strip of film stock, thus producing a single negative of the double print, from which single negative as many double-printed positives as may be desired may be had, with less trouble than making the total number of double prints.

Double Exposures. The making of ghosts by double exposures has been discussed. An explosion in the midst of a number of men may be made by making an exposure of many feet of film in which at a given signal the men all act upon the cue that the explosion has occurred. The camera man then goes to a black background, having noted the place in the film at which the explosion cue occurred, and runs the film from that point upon an explosion which produces a large amount of white smoke. In the projected picture, the men will be seen enveloped in the smoke of the explosion, which did not occur perhaps until next day. This effect might be made double by printing with the negatives together.

It is desired to photograph the semblance of an actress swimming in deep water, presumably at the bottom of the sea. An aquarium is photographed, or an aquatic background scene is photographed upon the motion film. The actress then is attired in light color, the camera is attached near the ceiling or mounted in the rafters, the actress lies upon the studio floor and simulates the movements of swimming. In the finished picture she is seen swimming among the details of the aquarium or aquatic background scene.

Mirrors. The appearance of a character in a scene may be effected by a mirror upon the stage, the actor standing off the stage but in view of the camera through the mirror at all times, appearing in the picture according to the amount of light which he receives from lamps near him. When lighted he is seen in the play; when darkened, he is not seen.

By mirrors also the effect of diminutive characters upon the stage may be effected. A table is backed by a mirror which is not noted except as a part of the paneled wall. In the mirror is visible an actor who really stands beside the camera. Owing to the greater distance of this reflected actor from the camera, he will appear of shorter stature than those actors who are viewed directly by the camera without reflection. Thus a fairy of diminutive size may be made to appear.

The secret of success in this illusion rests upon the accuracy with which the reflected image is placed in the picture, and upon keeping out of the picture any intermediate objects between the reflected actor and the directly photographed parts of the picture.

Such a picture may be made by double exposure, by double printing, by mirror, or by blackroom methods.

Blackroom. In making a negative of a single figure which is to be printed in with another scene, or in making the second exposure of a double exposure, the stage is hung in black or non-actinic color value.

With a black stage, the distances of all objects on the stage are deprived of their perspective values since all connecting features of the stage are invisible photographically. A man sits at a table near the camera. The camera lens is level with the table top. Upon the distant side of the room a girl is dancing upon a black platform of the height of the table. To the eye of the camera, the dancer's feet just touch the table top, but because of her distance the image is proportionately smaller than that of the man. The resulting picture shows the man sitting at a table upon the top of which is dancing a fairy no more than ten inches tall.

Stop Picture. The dummy picture is called a stop picture because the camera is stopped while the dummy substitution is made. Pictures in which sudden appearances and disappearances are made, are called stop pictures because the camera is stopped while the actors remain frozen. There is another type of stop picture to which the name is particularly applicable, the camera being stopped after every exposure.

Means. A camera making one exposure with one turn of the handle, and which may be left always with its shutter closed by leaving the handle in a latched position.

Effects. By the stop picture it is possible to give inanimate objects the appearance of life. Dolls are made to walk. Toy animals of the "humpty-dumpty" type are made to perform circus feats. Saws are made to cut off boards without hands; hammers are made to drive nails without hands; shoe laces tie themselves, etc.

Method. The stage being set, the handle is turned once on the camera, making one picture, or perhaps several at the beginning before starting the action. The handle being left in its latched position, with the shutter of the lens closed, the moving object of the stage setting is moved slightly. If a box of matches upon a table top is the subject of the picture, the inner box is pushed from the cover a sixteenth of an inch. The handle of the camera is turned once. The inner box is pushed an eighth of an inch; the handle is turned again. The inner box is pushed another eighth and the handle is turned again, the person or the hand which moved the match box having been safely out of the field of the camera before the crank was turned. The box being opened a little farther and a little farther each time soon is far enough open to permit the matches to be extracted. One match raises one end to the edge of the box; the handle is turned once. The match is advanced a sixteenth of an inch and the handle is turned again; another sixteenth, and another, and the handle may be turned several times without moving the match, giving the match the appearance of having paused in its motion to observe whether it is being watched in its escape from the box. Careful study of the extent of each motion of the match and the direction, and the taking occasionally of more than one picture between moves makes it possible to give to an inanimate object a wonderful simulation of life.

This class of stop pictures take unlimited time. Perhaps it is a job for rainy days in the studio.

Film manufacturers are permitting the popularity of trick pictures to decline because of the expense of producing them. The time consumed overbalances all features of apparent economy over ordinary methods for producing the legitimate motion picture.

SCENE FROM "NAPOLEON IN 1814," BY GAUMONT
An Interesting Study of the "Man of Destiny" in His Attitude Toward His Subordinates
Courtesy of the *Kleine Optical Co., Chicago*

WE WILL SELECT THE HOMLIEST ONE
Scene from Photoplay, "Oh You Teacher!"
Courtesy of *Essanay Film Mfg. Co., Chicago*

MOTION-PICTURE THEATER

MANAGEMENT

It is stating a platitude, to say that a motion-picture theater will not operate itself at a profit. If such a condition ever existed, competition and the multiplication of theaters has eliminated it from the ordinary, and has made such instances rare, if not obsolete. Picture theaters from time to time close their doors and go out of business because they do not pay a profit, and others "change hands" because the manager has found that he is making less money operating the theater than he could make doing something else. If the theater would only "operate itself" and pay a profit merely by the condition of its existence, the manager might be a negligible quantity in the picture theater, and his personality, his duties, his special training, and the limitations of his business might be neglected in a book of instruction whose scope is to cover the entire motion-picture industry.

The "Sick" Motion-Picture Theater. A picture theater is giving service to the citizens of a district of the city, conjointly with several other theaters in the neighborhood. Each gets a share of the people who seek entertainment in the evenings in that portion of the city, but one of them, it will be assumed, gets less than the others, while its cost of operation is about the same. It is only a matter of time until the familiar sign "This Place Has Changed Hands" will be seen, the place is closed for a week to emphasize the change of ownership and to advertise the new opening, a few changes are made in the theater, and business is begun again. From this time on, it gets its full share of the neighborhood's theater traffic, or even more.

What is the change? The only fundamental change is the manager. The new manager has brought with him either a knowledge of the motion-picture theater business, or an ability to learn the business while running his theater. The new manager understands from experience or study, or is able to learn and understand, not only his theater itself, but the people, *his people,* his patrons who come to his theater. They are his people, for he makes them his. He studies them, learns them, pleases them, and gets their money.

Several instances of change of ownership have been studied especially for the purpose of setting forth the observations in this book in order that theater managers might profit by them.

Change of Management (*1*). There were three theaters in the same city block, with no other theaters within three city blocks in either direction. The difference in traffic among the theaters in the block was easily noticeable to a motion-picture scout who gave the following two reasons why one of the theaters got less business than its proper share. *First,* it was the oldest of the three and had the least attractive front, each of the later houses having been designed to surpass the older house in outside attractiveness. *Second,* it was at the distant end of the block from a busy cross-street, so that the larger number of people coming to that block reached the other two theaters first, and could reach the oldest theater only by passing the other two.

When the place "changed hands"—an event which came to pass just after the midwinter holidays—the only new element in the theater was the new manager. The place was not even closed for spectacular effect of an "opening night." The new manager, however, was noticed at once. He took upon himself the duties of usher in his theater, and made it a point to stand at the exit door as the patrons who had seen the show came out. If a patron chanced to glance at him, the glance was met with a smile and a remark, "Call again," or "Good night," or "Did you like the show?" or, apologetically, "We are not so crowded except on Saturday nights." He was studying his people as they came out of the theater; he learned them, and they learned to know him and came to expect him to be there. Many of them learned to express praise of a good program which had pleased them particularly, while others by such questions as "When are you going to have another Biograph?" or a compliment upon any specific film picture, told him just what pictures were pleasing *his* people. He began to put out signs of "Good Selig Tonight" and "Repeated by Request," from time to time, and gained for his theater its just share of the business of the block.

Under one manager, this theater failed; under another manager the same theater, unchanged except as to manager, succeeded. The pay roll was the same, the quality of film about the same, the projection about the same; but the manager tried to learn what films would please his people, then obtained that class of subject and from popular factories, and advertised in front of his theater in the particular manner which he found best to attract his passers-by.

Change of Management (2). Of three theaters in two adjacent blocks in a city, one had a front of really artistic design in mission style, finished in the dark stain familiar in mission furniture. This place "changed hands" during the summer. The new manager painted that mission finish a pure white, just like the other two theaters, his competitors. A handsome wall sign at the entrance, containing the announcement of the films, and decorated with miniature electric lights, completed the only changes noticeable as improvements. The "Happy Hour" always had had as good a program as its competitors in the next block, but from this time on it had also just as good a patronage as they.

Change of Management (3). A small "store front" theater in a large city was located on a cross-street near the principal retail business street of the city. The owner and manager lost money all through his lease of a year and at the end of the year was glad to sell his fittings at a sacrifice to relieve himself of the burden of removing them to vacate the building for the owner. The purchaser was an experienced motion-picture theater man, running two theaters on other streets in the same city. He studied the location (before purchasing) and saw that the situation was peculiar.

Because the theater was located on a side street, the crowds of shoppers did not pass its door. Just around the corner, on the main business street for shoppers, were two other picture theaters, taking the trade of the shoppers and leaving the side street theater almost deserted. The experienced theater man saw that this theater location did not have an equal chance to obtain the patronage of the shoppers, but he conceived the idea that there must exist a class of people other than empty-headed shoppers strolling into the first open theater door, and he decided to buy the place, thoroughly renovate it, put in a sloping floor, and make an appeal to a special class of patrons by offering a special class of program.

The old show had been running a program of two reels of film, a new reel and a holdover each day; one song illustrated with lantern slides and changed twice a week, the singer being the pianist; and one vaudeville act. This program was given for five cents. The new manager reduced the size of the picture screen, thereby giving a brighter picture and reducing the jiggle of the picture while still using the same projecting machine. Then the vaudeville act was eliminated and a really good singer was employed. The picture films were changed to a program of "daily change" of the two reels without holdover—for this manager hoped to build up some patronage with office and store people who would come every day, either noon or evening. To this end, his song was changed every day. This gave him a complete change, both pictures and song, every day, with a short program of only about forty to forty-five minutes, but with the quality at the very top, particularly in the matter of the music.

The result was unqualified success, and profit. The difference lay in the training of the manager. The first manager did not understand his environment thoroughly, and tried to run a downtown theater for shoppers on a street where there were no shoppers; the new manager recognized this limitation of location and did not strive to fight against it, but instead reasoned that there must exist in that section a *clientele de luxe*, a class of busy people with an inclination for good music, and who would come every day for a short program of high quality. His success with the theater formerly a failure has proved his wisdom.

Change of Management (*4*). This theater was one of two, about a block apart, on a business street through a residence district of a city. It was run by a man who owned the store building and who, lacking a tenant, thought it only necessary to put in a theater front and a picture screen and hire an operator and a film service. He did not make his rental value. A young man living in the neighborhood and working downtown during the day offered to take the management of the theater, which was open evenings only. This young man had no experience whatever as manager, but studied the traffic of the neighboring picture show close enough to see that the only difference between the two shows was the quality of the films and projection. He took the management of the house, changed his film service, hired a good projection operator—thereby increasing the running expenses—put out a "changed hands" sign to induce the people to make a trial visit, advertised a special program with hand-bills every week, and got his share of the trade from the first week.

In this case, the first manager made a failure because he did not study his own theater to find out what was the matter with it. The second manager made a success, because he studied the two theaters comparatively to learn wherein the one which he thought of taking was inferior to the competitor, knowing that it was necessary only to equal his competitor to obtain his half of the traffic, and knowing—from a head count and an expense sheet—that half the traffic in his theater would pay him a profit.

Change of Management (*5*). This case was pure economy in pay roll. One man started a store-front theater and quit before the end of the first winter. The second winter, another man started in the same store, ran it for two winters, and continues to operate it. This picture show is isolated, being in a small town, the only show in the town. The man who ran this show for the first winter knew nothing of the motion-picture business. He furnished a store room with screen and chairs, a piano and a projection machine, hired a pianist, an operator, and a film service, and started the show, acting himself as doorkeeper. The show ran evenings only, and paid no profit. The owner concluded that the town was too small to support a motion-picture theater, and closed the house.

The second manager, who ran the theater the second year, was a projection operator. He did not take in any more nickels than the first manager, but he paid less money to his pianist, he got his film service at a lower figure because he knew what he could afford and did not pay more than it was worth, and, being the projection operator himself, he did not have that expense to deduct from the receipts before calculating his own personal profits from the show business. The net profits to him were such as enabled him to run the show year after year, and to prove that the town would support a motion-picture theater when the theater was run by a manager who understood the limitations of his field and governed his program and his expense sheet accordingly.

Art of the Manager. These illustrations of theaters which have failed under one manager and then have succeeded under another, every one with only some small difference in paint, or program, or pay roll, are given to illustrate the statement that in many if not nearly all cases the element of success or failure lies with the manager.

Every one of the instances show merely that the new manager adapted his theater to the conditions which he found existing as limitations upon the theater when he took charge of it.

In the example (1), the new manager decided to make his theater different from his competitors by learning the particular things which would please his people and by giving them a personal courteous attention. He won success.

In the example (2), the new manager decided that his theater was as good as his competitor's except that it had a sober front, almost repellent to the joy seeker. He changed the color of the front, and won success by eliminating his theater's handicap.

In the example (3), the new manager decided that an ordinary theater could not be run successfully in that location, so he tried an extraordinary program, and won success.

In the example (4), the new manager decided that his theater had only one handicap over his competitor, the quality of films and projection. He removed this fault, and won success.

In the example (5), the new manager saw that the expense could be reduced even though the receipts could not be increased, and his profit lay in the difference. Notice that he did not give a poorer program, but gave the same quantity and quality program at a smaller expense.

In (2) and (4), the new manager found a single feature in which his theater was behind his competitors; he brought that feature up to his competitors and won his share of the business.

In (1), in (3), and in (5), the location of the theater was not good, but each of the managers found a different solution; in (5), it was simple economy; in (1), it was personal attention to the likes and dislikes of his patrons; in (3), it was a Napoleonic stroke of generalship.

Reviving a "Sick" Picture Theater. There is only one symptom which attracts attention to the disease of the theater, and that is the lack of satisfactory net profit. This symptom may be due to either of two diseases: *first*, that the income is not large enough; and *second*,

SCENE FROM PHOTOPLAY, "THE LAST APPEAL"
Courtesy of *Independent Moving Pictures Co., New York*

LEONORA BEGS TO BE PERMITTED TO SEE MANRICO
Scene from Pathé film, "Il Trovatore"
Courtesy of *Pathé Frères, New York and Paris*

that the expense is too large. In example (5), the new manager did not think the income could be increased, but he reduced the expense. In examples (1), (2), and (3), the new manager did not decrease the expense, but by his skill he increased the income. In example (4), the new manager found both income and expense too low, and increased both, increasing the income more than the expense.

The "sick" picture theater must be studied particularly with reference to its competition and its location. Then the traffic of the community must be studied to learn whether there is sufficient traffic to support the theater. The question of traffic may be studied in two phases: *first*, whether there is enough to support the "sick" theater if it were to get its proportion of the total; and *second*, whether it is necessary or advisable to try to surpass competition and secure for the "sick" theater more than its proportion. The second proposition is a case for a doctor of experience.

Competition. Study every point of difference which can be found between the theater in question and its competitor or competitors: The color of the front; the decorations of the front; the announcement signs for number, attractiveness, and general desirability; the poster service used for the films; the style of ticket window; the courtesy of the cashier; the method of taking the tickets at the door and the courtesy of the doorkeeper; the seat arrangement; the width of aisles and the confusion or convenience of incoming and outgoing patrons when the place is handling a crowd; the comfort of the seats, their style, their width, and the space between the rows, whether cramped or liberal to permit passing an occupied seat; the number of seats; the decoration of the walls; the illumination during the pictures and during the intermissions; the quality of the films, whether new or old and whether clean or dirty or scratchy; the quality of the projection, whether dim or brilliant, whether steady in light or full of flicker, whether steady in position or full of jumps and jiggles on the screen, and whether the whole picture on the screen rises and falls with a wave-like motion; the quality of the song slides and their projection; the quality of the singer; the music or entertainment during intermissions in the program; the character of the vaudeville, and whether it suits the audience or displeases them, being endured only for the remainder of the program; the frequency of change of program, pictures, songs, and vaudeville.

When a point of difference is found, study it to see whether the difference is to the advantage of the theater under study or whether it is to the advantage of the competitor. Then decide whether any change should be made in the theater studied.

The result of this study should determine whether it is possible at a reasonable expense to bring the theater studied up to equality with its neighbors, and the study should permit the making of an expense sheet for running the theater in equality with its neighbors. The new expense sheet may be smaller or larger than the old; that is immaterial, for the question is: "What will be the expense of making this theater equal to its neighbors or competitors that it may divide the trade with them?"

Traffic. An actual "head count" of the patronage of the neighboring or competing theaters must be made, and a count of the number of people "held out" during the heavier hours of traffic, if such occurs. Add the total of all admissions for the theater studied and its competitors, and divide by the number of theaters for the hours of lighter traffic and divide by the number of seats in the capacity of the houses for the hours of heavier traffic when patrons are being held out at the door. This will give the revenue to be expected in the theater studied if it were brought up to quality with its competitors.

Income vs. Expense. The two amounts thus obtained—the income from the ticket window and the expense account for equaling competition—will give the profit of the theater without consideration for side lines of profit.

The ticket-window profit may be increased by a judicious use of side lines for profit, unless the matter of such devices has been abused and thus brought into disrepute in the neighborhood.

The side lines which may be considered are: (*1*) paid advertising on a drop curtain, displayed during intermissions; (*2*) paid advertising slides for the stereopticon; (*3*) paid advertising space on printed programs handed to the patrons either on entering or leaving the theater; (*4*) paid advertising on hand-bills containing theater announcements and distributed through the neighborhood; (*5*) sales of candy in the theater during the intermissions; (*6*) control or co-operation of a confectionery and refreshment business adjacent to the theater; (*7*) automatic slot vending machines.

Managing a Theater for Profit. Continuous study of the theater, day by day and week by week, comparing it with its competitors and comparing it with other theaters at a distance but similarly located, similarly surrounded, and similarly equipped, will enable the manager to determine just what his theater ought to do in the way of gross receipts, expense, and net profits. This gives him a theoretical result which should be attained by his account books. If his books do not show the amount of profit, and from the different sources, which his study shows, he should study his theater as a "sick theater" and strive to learn why he is not doing as well as his competitors, or as well as some other theater operated by another manager under comparatively the same conditions. A study of other theaters, near and far, a study of the technical papers, and a study of the advertising and educational matter constantly sent out by manufacturers in the motion-picture industry, films, machines, accessories, and sundries, will give the manager a correct idea of what his theater should accomplish. Then he may study his own house to learn whether it accomplishes what it should, and if not, he may learn by still further study what is lacking that prevents it from attaining daily its just deserts and its maximum profits.

STARTING A THEATER

The first detail is to choose a location, then to decide how extensive an investment the location will justify because of its prospective patronage. After that, the building and operating of the theater becomes routine detail, the theater succeeding or failing according to the ability of the manager, his attention to the details of the theater and its patronage, and his ability to learn and understand the salient facts in his studies.

Selecting a Location. *Among Competitors.* In this case, the proposed location may be studied as though the site were already occupied with a "sick theater." The traffic upon the existing theaters may be tallied up and expressed in dollars per week; then a reasonable increase may be figured, for a new theater added to the ones already existing will increase the total of the traffic. This total may be divided to learn how much money will be taken at the ticket window of the proposed new house. Side lines for profit then are studied and added, the total income and the total expense are obtained and compared, and the answer is obtained to the question: How much will another theater in this locality pay in profits?

This study may be made upon the basis of another small store-front theater competing with one or two already established, or it may be made upon the basis of constructing a larger theater. If a larger theater is to be compared with a store-front competitor, the total traffic may be increased largely, say doubled, for the larger, more pretentious house will draw traffic over a larger area, for a greater distance both ways on the street, and then in turn will take a larger share as its proportion of the total, particularly in view of larger seating capacity on the rush evenings when all houses are holding the patrons out for want of seating capacity.

New Territory. The only difference is that the traffic to be expected is more indefinite in calculation. It may be predicted very closely by a "head count" of the people passing a possible location. The count should be made every evening for a week, or during all such hours of the week as the theater would be open for business. In the absence of other data, this number may be divided by ten to obtain the number of nickels which may be expected, or one-half cent for each person passing the possible theater. Towns vary in this respect. To obtain the proper figure for the town in which the possible theater is being studied, go to other theaters in the town, count for a few evenings the number of people passing the theater and the number of people passing into the theater, and learn whether the theater gets one out of eight, or one out of twelve, or one out of twenty who pass the door. To the casual mind, the following law may seem without reason, but it will hold true: *The proportion of people who pass into an ordinary picture theater to the people who pass by will be about the same in all parts of the same city, and the patronage of a theater in open territory may be predicted from a count of passers at the site where it is proposed to start the theater.*

Having thus by "head count" obtained a figure for the ticket window receipts, the expenditure for establishing the theater, and the pay roll for operating it may be determined in advance, and a theater may be built in that location which will pay a reasonable profit on its investment and running expenses—in short, a successful theater may be established, because it will be established in harmony with the possibilities of its location and environment.

A person looking for a theater location will find many "possible" places where he might rent or build and start his theater. All of these, or at least several of the more promising of them, should be studied carefully and in detail, making up an income and expense account for each of the locations; then the best may be selected and the theater started.

Small Town. This is a case for study, not so much to determine the place in the town where the theater should be located, but to determine whether the town itself is a suitable location for a theater, whether it will support a theater and how much of an investment and pay roll will be justified.

The "head count" for a town so small that only one theater is possible may be taken from the census reports. Any town of 1,000 people will support a motion-picture theater if it is run by the right man and in the right way. It is found that a "one theater" town will pay weekly at the ticket window from two and one-half to five cents per capita on its census population. A town of 1,000 people will yield from $25 to $50 per week on a show running six nights per week and Saturday afternoon or whatever day of the week the country people use for market day, usually Saturday, but not always.

The gross revenue of the small town being determined by multiplying the census population by a reasonable amount to be expected, say three and one-half or four cents per week, it remains for the prospective theater manager and owner to decide whether he can bring his expense sheet sufficiently below the gross receipts to leave an acceptable profit for his time and whether with such an expense sheet he can give an acceptable show which will continue to bring the money after the first few weeks, when the novelty of the theater has worn away.

The manager must make himself thoroughly familiar with any city ordinances regulating the operation of motion-picture theaters. Even small towns are having such laws enacted.

Financing. For the man who believes that he can make money in managing a picture theater, whether he has experience in the picture theater business or not, yet who has not the necessary funds for starting it, there occurs the problem of securing the money, and upon such terms as will yield him a profit and not pass all the profits to the capitalist who furnishes the money and does no work.

For a small enterprise, which will not require more than, say $2,000, with anticipated profits (excluding manager) of $50 to $75 per week, the manager and promoter may profitably arrange to "split the profits" with the capitalist. This will yield the manager a revenue of $25 to $37.50 per week if he can run the theater according to his expectations, while the capitalist, who is sole owner of the theater under the agreement, will receive a liberal return on his investment, even allowing for depreciation of the theater fittings.

For a larger enterprise involving much more capital the capitalist may insist upon an unequal division of profits, because the anticipated salary for the manager and promoter would look large. In such an instance, the manager should insist upon a fixed salary for himself carried as a part of the expense pay roll of the theater; and in addition an unequal division of the net profits, giving the capitalist the greater portion.

For any enterprise where more than one man puts up any money, a form of stock company or partnership agreement should be drawn up and signed by all. This cannot be much more than informal unless placed in the hands of an attorney-at-law for proper form, but in any event it should be a signed agreement. In such a financing plan, the manager operating the theater will receive a salary as a theater expense, and all profits will be divided by the partners or stockholders in proportion to the amounts of money each of them furnished. A share of the net profits is provided for the manager and promoter by giving him a share in the ownership which he earns by his work in organizing the company instead of by paying cash. This may be one-tenth to one-half stock interest or ownership.

A Store-Front City Theater Building. A vacant business house having been selected both for location and for size, the process of converting it into a motion-picture theater is to remove the glass front and framing for the door and window, to replace it with a closed front a few feet back from the sidewalk line into which are built the ticket seller's booth and the entrance and exit doors and on the inside of which is built the projection operator's booth. At the inner end of the room a muslin screen about 3 by 4 yards is stretched. The room is filled with rows of chairs, either kitchen chairs or opera chairs, as the expense justified by the location will permit, and a piano is placed near the picture screen.

Floor Plan. A few general rules which may be followed in floor-plan construction are given herewith; aside from these a large variation in floor plan is possible.

The projecting machine should be at one end of the room and the picture screen at the other end, both being so high above the floor that the rays of light from the projecting machine to the lower edge of the screen will not be interrupted by patrons passing down the aisle.

The front of the room must be closed against the lights of the street, even when a patron is entering.

The operator's room must be laid out with reference to comfort and convenience, 6 feet square is a desirable smaller limit.

The floor space, if limited, must be laid out to seat as many people as possible, up to the number which the traffic study will require.

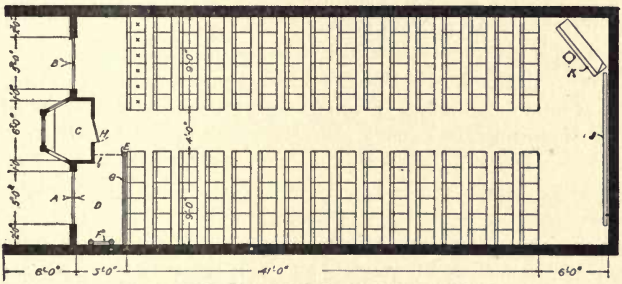


Fig. 1. Floor Plan for a Small Store-Front Theater

The operator's booth must be lined with sheet iron, top, bottom, and sides, with a door having a latch, and with two look-out holes, one for the beam of light from the lenses and another at least a foot square and with the center at the height of the operator's eye, through which the operator may look to see his picture on the screen; these requirements are for protection against fire.

A floor plan which is adaptable to the general requirements of any store-front theater is given in Fig. 1. This shows an arrangement for the maximum seating capacity for a store room 22 feet by 58 feet inside the walls. The seating capacity shown is 192. The front partition of the theater is placed 6 feet back from the sidewalk. The ticket booth extends forward from this partition. A still deeper front is desirable if the floor space can be spared; it gives advertising space;

it gives opportunity for decorative efforts without the expense of decorating the entire front of the business house; it suggests retirement in the theater, and when the prospective patron steps off the sidewalk he feels that he is already within the theater, even before he has purchased his admission ticket.

The entrance and exit doors in the partition should be double doors. The entrance doors at *A* should swing both ways, while the exit doors at *B* should swing outward but not inward.

The ticket booth in Fig. 1 is 6 feet by 5 feet inside, with a shelf 1 foot wide across the front for making change. The three glass windows should be made with removable sash in order that screen wire or grille may be substituted in the warm weather.

The operating booth occupying the upper part of the space *D* is built over the ticket booth upon an elevated platform about 5 by 9 feet in size. As the patrons of the theater are required to pass under this platform it should be built upon a platform about 7 feet from the floor. A stanchion is set from floor to ceiling at *E*, about 9 feet from the side wall and 5 feet from the partition, and with this stanchion as a corner post a platform is built to cover the space *D*, then closed in with walls from the platform to the ceiling to form the operating room. Windows for projection and lookout are left in the wall toward the screen *J*, and another window may be left in the end for ventilation and over the doors *A* in the partition. Entrance to the operating room is obtained by means of the ladder at *F*, which extends upward along the wall and through a hole about 30 inches square in the floor of the operating room.

Below the operating-room platform, extending from the stanchion *E* to the wall, a screen *G* should be placed to prevent the light of the street from reaching the screen when the doors *A* are open; this may be a curtain hung from the edge of the operator's booth. The doorkeeper stands at the post marked *H*. A movable chain or bar is provided to extend from the stanchion *E* to the wall of the ticket booth to close the passage at the dotted line *I*. This enables the doorkeeper to hold back patrons who come so near the close of a picture or act that they would be interfered with by patrons passing out, or by patrons for whom there is no seat.

The piano may be at *K*, either automatic or manual. The screen *J* is shown at one side of the center; this has two advantages in the floor plan as shown. It gives more room for the piano and singer at the side of the screen, and it brings the center of the screen nearer to the direct line from the projection machine at the end *I* of the operating room at *D*.

Another method of building an operating room is to build it over the cashier's booth, extending through the partition and projecting into the theater room as far as the stanchion *E*. Set two stanchions like *E* and build the platform to the ceiling, placing the ladder *F* beside the short wall of the cashier ticket seller's booth, just inside the entrance door. The projecting machine will stand against the wall of the operating room at the exit-door side, and the projection and look-out windows should be placed in the front wall accordingly.

A space of 6 or 8 feet between the front chairs and the picture screen should be allowed, as the pictures cannot be viewed at a very close range. If the seats marked *X* are left out, the added convenience to patrons in passing out of the theater may more than compensate for the decreased seating capacity.

Lighting Methods. Ceiling lights, say a sixteen-candle-power lamp for each 50 square feet of floor, should burn during the intermissions. Shaded wall lamps, say an eight-candle-power lamp every 10 or 12 feet along each wall, should burn all the time, including the time during the pictures. The wall lamps should be so shaded that the light will not shine upon the picture screen nor upon the eyes of the audience.

The term "daylight-theater" is used to designate a theater in which the auditorium lights are not turned off during the projection of the pictures. This result is attained by hanging the ceiling lamps in sixty-degree conical shades, or the equivalent in ornamental shades, so that the light from each ceiling lamp covers a circle on the floor under the lamp but does not shine on the picture screen, nor does it shine back toward the entrance into the eyes of the seated patrons. The lamps thus shaded must be distributed over the theater ceiling, and not grouped, as then the desired effect would be lost.

Low-Cost Store Front. To build for the lowest cost of starting operation, in a location where only the minimum expense is justified or where only the minimum expense is desired, the front partition may be modeled upon the style shown in Fig. 2. This is all simple carpenter work and painter work. The complete change in the store room, ready for chairs, piano, wiring and projecting machine, should not exceed $150; 200 chairs of the kitchen variety at $100; electric lamps and wiring at $100; a projecting machine at $165; and a rented piano—the total expense amounting to about $500. With a small additional amount for supplies and initial advertising expense, the manager will be able to open his doors to the public at a total cash expense of not more than $600, and no debts.

Only country towns of small size without competition, or un-

Fig. 2. A Simple Front Design for a Store-Front Theater

occupied or non-competitive city territory, will permit a successful theater with so simple an establishment.

Such a theater could be established upon a prospective ticket sale of $110 to $150 per week, since the return for the manager's labor and a return for the cash invested must be earned in addition to the expense sheet given below. The item of "Supplies" includes tickets, carbons, condensers, lamp renewals, machine repair parts etc., and piano tuning, including in this case also the rent of the piano. This is a fair expense account for a small city house, even though at a much larger initial cost, where competition does not compel a larger expense, yet where the patrons constantly are comparing this residence district theater with the more pretentious down-town motion-picture theaters. With such distant competition for comparison, it is necessary to maintain a quality of picture projection and music which will stand the comparison, if the theater is to be a continued business with profits.

The cost of operating this theater, evenings only—for it would be either in a small town or in a residence territory of a city—for a program of two reels of film and a song, would be, by the week, about as follows:

Rent and heat	$ 10.00
Electricity	5.00
Film	20.00
Song Slides	2.00
Supplies	13.00
Operator	15.00
Cashier	3.00
Doorkeeper	5.00
Pianist	5.00
Singer	5.00
Weekly Expense	$ 83.00

In a non-competitive small city, not only will the rent be lower, but the wage rate will be lower throughout.

Elaborate Store-Front. The floor plan will be the same in this case as in Fig. 1, the difference being found in the quality and appearance of the elements going to make up the theater.

A decorative front such as is illustrated in Fig. 3 will cost $500 to $2,000 for the front partition complete with operating room and cashier's booth, including all the decoration in front of the partition. Another $500 or more will be needed to raise the floor and to install 200 opera chairs at $1.20 to $1.60 each. The inside decorations and the picture screen of modern type will raise the expense $200 to $300 at least. The total expense need not exceed $6,000; with any pretensions toward beauty and luxury, it cannot be kept below $2,000.

For designing and building the front, a firm in the special work should be employed, unless the manager who is starting the theater is of long experience and knows exactly what he wants. The large number of such theaters which have been built has developed construction firms and workmen particularly skilled in such work, whose very presence on the job will insure that refinement and perfection of detail which the manager desires but which the inexperienced

Fig. 3. A Decorative Front Design for Store-Front Theater.

manager employing inexperienced workmen is likely to overlook, leaving his house inferior to those of his competitors.

In selecting or approving a plan by a professional designer, the manager should see that the cashier's booth is large enough for comfort all the year round and that the projection operator's booth is large enough for two operators and two projecting machines. Not only may competition enforce the employment of two operators, but it will be found positive economy to give the operator an assistant during the rush hours of Saturday night.

In a house of this class, a manager's control panel and signal system should be installed at the door where the ticket-taker stands, that he may signal the operator to begin projection, and may ring for the singer, etc., controlling the conduct of the program particularly during the rush hours when the passing of numbers of people in or out may delay the beginning of the next picture.

The program selected—by this term "program" is included the quality as well as quantity of pictures, song, music, and vaudeville—must follow the custom of the city in which the theater is located, if the certainty of a proper division of patronage is desired. A departure from the custom of the city may result in a larger success, or may result in failure. Such a departure was made in the theater discussed in "Change of Management (3)," and serves as an example.

A specimen expense sheet of a high-class store-front picture theater is here given.

WEEKLY EXPENSE SHEET

Rent, of complete theater, week	$ 40.00
Film rent, three reels daily change	50.00
Carbons	1.00
Pianist	15.00
Violinist	10.00
Drummer	12.00
Usher	2.50
Electricity	18.00
Song Slides	2.00
Cashier	5.00
Singer	18.00
License	4.00
Projection operator	18.00
Porter	4.00
Ticket taker	5.00
General Expense	10.00
Total weekly expense, not including manager	$214.50

Receipts, average, six nights $240, Sunday $100; total weekly receipts, average, $340.

Specimen Expense Sheet of a High-Class Store-Front Picture Theater. The figures given above are the actual expense sheet of a house of this class in a residence district of Chicago. The rent item is the amount paid per week, making a rental of $173 per month or $2,080 per year, but this is for the house equipped with chairs and projecting machine, so that the expense sheet is carrying the item of depreciation of investment as a part of the rent item. The cost of opening this house for business was in the neighborhood of $3,000.

This particular theater charges a five-cent admission seven days in the week. The seating capacity is 300. A one-hour program is given at 7, 8, 9, and 10 P.M. on week days and at 2, 3, 4, 5, 6, 7, 8, 9, 10 P.M. on Sundays—thirty-three shows per week, three reels and a song in each program. The film is one reel third-run, one reel not more than ten days old, and one reel not more than three months old, daily change, for which $50 per week is paid. Two different songs are given, alternating in every other program, with one singer. Music is furnished by an orchestra of three. The item of "Sundry Expense" includes tickets, coal, condensers, poster service, machine repairs, lamp renewals, piano tuning, etc.

In this theater, the manager takes profits rather than a salary. He has no capital invested, but in the $40 per week rent he is paying a return to the capitalist for the investment.

Sloping Floor. This method of floor construction raises the eyes of patrons in the back seats above the heads in the front rows, giving the patrons at the back of the house a better view of the picture screen or stage. The sloping-floor construction is necessary in houses classing above the simplest of store-front theaters. It is a good bid for business to equal or excel a competitor, because it gives a greater comfort to the patron, and makes the picture theater resemble more closely the larger, more pretentious city houses.

A side view of a store-front theater with one wall removed is shown in Fig. 4. This shows the sloping floor, and one method of constructing it for store-front houses. Where the building is erected specially for theater purposes, even though it be a part of a business block and a store-front in appearance, this plan is easily followed, but where an old building is remodeled it is necessary to cut the floor joists at the picture screen end if the entrance doors are to be level with the street or sidewalk.

A raised floor may be constructed upon the store-room floor by building a few low trestles or "horses" across the house, say 18 inches or 2 feet high at the street partition of the house, and getting lower toward the picture screen. Joists for the inclined floor are laid sloping upon these trestles, and taper to a point at the toe where the new sloping floor meets the old level floor. The slope may extend two-thirds the way to the picture screen, and the front third of the house may be level.

Steps may be built between the street level and the raised floor, or the floor may be sloped up from the street line to avoid steps, even carrying a slope into the aisle of the theater.

The floor plan arrangement for the street end of the theater of Fig. 1 is suitable for the theater of Fig. 4, or the projection booth may be built over the ticket booth.

In the theater of Fig. 4, the requirement for the height of the projection room floor and for the height of the projection window is that *the rays of light from the lens to the lower edge of the picture screen should clear the heads of persons standing in the aisle.*

A comfortable amount of slope for the theater floor is 1 foot in 8. This is the slope shown in Fig. 4.

Seats upon a sloping floor must be the *"theater seat,"* as shown in end view in Fig. 4; or if chairs the legs must be sawed to make

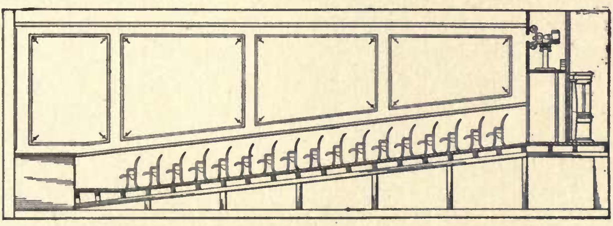


Fig. 4. Theater with Sloping Floor

the chair comfortable. When theater seats are bought, it should be specified that they are for use upon a sloping floor, and they will be furnished accordingly by the manufacturer. The seats between the bottom of the slope and the picture screen are ordered for level floor.

Stage. If a stage is to be built, either for vaudeville purposes, or for scenic effect in the theater, the stage floor should be 3 feet above the theater floor in front of the stage. The proscenium arch in such a stage may extend to within 1 foot of a low ceiling, and within 3 feet of each side wall.

If for decorative effect only, the picture screen may be stretched permanently across the opening. The projected picture should be kept a foot or two above the bottom of the screen.

If for use for vaudeville, the stage should be 10 or 12 feet deep, with two wings on each side. An interior flat should be at the back and a street scene half-way between the back flat and the drop curtain. The picture screen should be at the front, just behind the drop curtain. By "interior flat" is meant a flat painted scene showing the interior of a room. There may be two pairs of wings for the interior scene setting and one pair of wings for the street scene, with flies sufficient to conceal the ceiling from the patrons in the front row of chairs.

If the stage is used for vaudeville, footlights must be installed, with switch at the ticket-taker's station at the entrance, and the projection operator must be provided with a mask for his stereopticon which will cover the stage opening but not the sides of the arch.

Picture Screen. For a screen against a wall, the wall may be painted white, or given a "white finish" coat, such as plasterers use in finishing a wall smooth. Over this white surface, stretch a sheet of thin muslin, with as few seams as possible. Have the seams run horizontally, and tack the muslin all around the edges. A neat and inexpensive finish is obtained by nailing to the wall a frame of wide picture-molding, mitering the corners as though the screen were framed and hung upon the wall.

Any wall screen or drop curtain screen may be treated by a coat of paint containing finely divided particles of some glittering substance, such as finely-divided aluminum dust, or finely-powdered glass, or the curtain may be painted with any sticky paint and the metallic dust or powdered glass thrown or blown upon it and, when the sticky paint dries, a glittering surface will remain upon the screen producing what is known as the *metal-surfaced* screen. These tricks of producing metal surfaces are well known by sign painters.

The picture projected upon such a *metallic-surfaced screen* is more brilliant in its light portions, while retaining all the detail of its darker or shadowy portions. At the same time, the dead white screen may be a matter of personal preference, or where all competitors use a metallic surface, the dead white of thin cloth backed by white plaster cleaned from dust occasionally to keep it white,

TRAVIS' LAST STAND IN THE ALAMO
Scene from Photoplay, "The Immortal Alamo"
Courtesy of *G. Melies Company, New York*

HARVEY BARTON AND HIS SWEETHEART, KATE BOWERS
Scene from Photoplay, "The Puncher's New Love"
Courtesy of *Essanay Film Mfg. Co., Chicago*

and kept free from stains at all times, together with a smaller and brighter picture, may be urged as an advertising point of advantage over the methods of competitors.

The *mirror screen* increases the brilliancy of a picture. Also, it is likely to give "haloes" or radiant bright spots to some places of the auditorium if the surfacing is not sufficiently dense. The cost runs to $300 or $400.

The theoretical mirror screen as announced to the public consists of a sheet of plate glass, the size of the projected picture; this glass is silvered upon the back and ground to a smooth ground-glass finish upon the front surface. The ground-glass surface gives a good screen surface for projection, even if not backed, being equivalent to a surface of finely-powdered glass, but all light which passes through the ground-glass surface is reflected by the mirror back to the surface again and through it to the spectators in the theater. The result is a large increase in brilliancy in the picture projected with the same conditions of lamp and lenses.

Mirror screens are made also by painting the surface of a large mirror with a frosting surface, such as a thin mixture of English "whiting" with water and a little glue. A substitute for the real mirror screen is a mirror over which is stretched a sheet of thin muslin. The muslin should be seamless—muslin sheeting 8 feet wide may be obtained in the market—or the seams must be made by setting the two selvedged edges against each other and whipping them together with a very fine stitch without lapping the fabric. Where a lap seam is used, the mirror behind the fabric shows the seam so very plainly that it becomes decidedly objectionable.

The thin fabric screen backed by a mirror is an improvement upon the fabric screen backed by a white wall. The cheapness of such an arrangement is based on the fact that the mirror used to back such a fabric screen may be made economically of small sheets of silvered glass rather than of a single large sheet, the small sheets being set snugly together without bevel edges and without mounting, that the lines of joining may not be noticed by the patrons. Small clamps may hold the mirrors to a supporting wall or vertical platform, care being taken to make the entire mirror surface flat.

Where, because of clearing the stage for vaudeville acts, it is necessary to roll the picture screen, the screen must be made of opaque white fabric, and fitted with a heavy roller to stretch it when rolled down, or tackle must be used at the bottom to stretch it. A waving curtain produces a very objectionable effect in the picture. Metallic surfaces have been used on *roller picture screens.* Great care must be used to avoid wrinkles when the metallic surface is used, for the small wrinkles are much emphasized by the reflecting nature of the sparkling surface.

Special Buildings. A theater building having a 50-foot front and seating five hundred or more people may be built at a cost aside from the lot of $10,000 to $20,000, according to design and location. Such houses usually are run to a longer program than an hour of pictures, being vaudeville houses rather than simple picture houses.

The principles of operating such a house do not vary from those of the smaller picture theaters. The same tact, skill, and ability to learn from experience and from observation of other houses of the class are required of the manager. The same balancing of gross income against expense, and the same possibilities of side lines for additional profits, exist.

A house of this size in the residence districts usually runs a vaudeville program and charges an admission of ten cents or more.

Example of Special Theater Building. The class of theater occupying a specially constructed building, in the residence districts of Chicago, is well represented by the particular theater from which the following facts are taken:

The lot, 50 by 125 feet, upon which the building is erected, was estimated in value at $10,000; and the erection of the building and its equipment ready for the public, cost $15,000, making a total expense in the building itself of $25,000. For this investment the owner takes a rental of $5,200 per year from the receipts of the theater. This item is considered an item of rent in the theater expense sheet, and is paid weekly at the rate of $100 per week, as rent.

The program consists of four acts of vaudeville, two reels of film, and a song. There is an orchestra of four pieces. The program lasts about an hour and a half to an hour and three-quarters. The program is given twice each night, once on Wednesday afternoon, once on Saturday afternoon, and twice on Sunday afternoon; eighteen performances per week, of which four are on Sunday. In case of a long vaudeville program, the song is omitted.

The house contains 800 seats, of which 600 are on the main floor and 200 on the balcony. Of these, 350 seats are sold at twenty cents and 450 at ten cents; the total value of a full house is $115. An average evening in fair weather is a house and a half for the two performances. Of the twenty-cent seats, fifty are the front rows of the balcony; this raises the tone of the balcony as a seat location and helps to sell the house out when nearly full.

The film service is one reel ten days old and one reel not more than three months old, change twice a week; for this service, the price paid is $20 per week. The entire program, vaudeville and film and song, is changed twice each week.

The illustrated song slides, when used, and the singer as well, are furnished free by the music publishers for the advertising value.

WEEKLY EXPENSE OF A SMALL VAUDEVILLE THEATER

Rent, per week	$100.00
Film service, per week	20.00
Carbons	1.00
Orchestra of four pieces, per week	91.00
Two ushers	5.00
One fire guard	7.00
One stage manager	20.00
One stage helper	7.00
Electricity, per week	30.00
Cashier	7.00
License	4.00
Poster title service	5.00
Projection operator	18.00
Vaudeville, average weekly	500.00
Porter and watchman	12.00
Ticket taker	8.00
Sundry small expenses, average per week	25.00
Weekly expense sheet	$860.00

Average receipts for six days, fourteen performances, $900.00; for Sunday, four performances, $315. Average weekly receipts, $1,215.

Large Exclusive Picture House. Only in the shopping district of a city can a sufficient number of patrons be found to fill a large house repeatedly for short programs. The data given here for such a theater is taken from a theater on the busiest retail business street of one of the largest cities of the United States, a theater representative of the highest class of motion-picture theater.

The house is open fourteen hours per day, seven days each week, from 9 A. M. until 11 P. M. The program is three reels of film (or three pictures, not necessarily each a full reel) and two illustrated songs. The film is all first run, changing the three reels three times each week, without holdovers, but a good film picture frequently will be repeated a few weeks later, with the advertising sign, "Repeated by request." The songs are changed weekly. Two singers are employed for the two songs of each program, one male voice and one female voice.

Three projection operators, working at the same time in the operating room, put on the program. Two of these operators have motion-picture projecting machines, while the third operator projects nothing but stereopticon slides, both announcement slides and song slides, attending also to the illumination of the auditorium during the intermission.

The order of the program is as follows: The show starts with a few announcement slides; then the first motion-picture operator puts on the first film picture. As the end of the film picture approaches the stereopticon operator stands ready and projects the song title upon the tailpiece of the film, the pianist opens the introduction to the song as the title appears and the song follows without a second of lost time. At the close of the song, the second motion-picture operator stands ready and begins projection at a signal from the stereopticon operator, the last slide of the song dissolving into the title of the next film picture. In the same manner the screen continues without interruption of projection into the second song and then into the third film picture by the first projection operator. At the close of the third film picture the lights are turned on, the crowd is allowed a few minutes for passing out and in, the candy man makes a trip, and the program is repeated. The house is "dark" about fifty minutes for the program of three pictures and two songs, and is "light" for about five minutes for the intermission.

For the ordinary day, fifteen performances are given in the fourteen hours. On Saturday, the busy day, an extra performance is given, making sixteen in all.

The house, equipped fully for the operation of the theater, represents an invested capital of $160,000. The building was completely remodeled for the theater, under lease to the theater managers. It is not owned by the theater managers, and a rental of $48,000 per year is paid. This includes heating. Figured upon a weekly basis for the weekly expense sheet, this rental is $923 per week.

The theater seats seven hundred people. The admission price is ten cents, anywhere in the house, giving a value for a "full house" of $70.

The attendance averages about six-tenths of the total capacity

—six-tenths of seven hundred seats, filled fifteen times on an average for six days, 6,300 tickets per day for six days and 400 more on Saturday for the extra performance, about 44,500 tickets per week, or $4,450 weekly receipts at the ticket window. On many Saturdays —the busy day with sixteen performances—the ticket sale reaches nearly 10,000, or $1,000.

The theater is operated by two sets of employes, called the day force and the night force, each working seven hours continuously. The day force works from 9 A. M. until 4 P. M., the night force then coming on and working until 11 P. M. Thirty-five employes are on the pay roll of the theater itself, aside from the manager and his clerical help.

The orchestra comprises pianist and drummer, and a "sound effect" man for adding something of realism to the pictures by supplying some of the sounds attendant in nature upon the scene represented.

WEEKLY EXPENSE. The item of rent is a matter fixed by contract with the owner of the building. It appears high when compared with rental values of theaters of similar seating capacity but located in the residence districts of the city where the land values are not so high.

In the item of electric current, it must be noted that this theater runs fourteen hours per day, against an average of five hours per day for a residence district theater. The electric lighting and electric signs in front of the theater are profuse, and most of the lamps burn the full fourteen hours per day that the theater is open.

The film rental item of $126 per week for three reels changed three times a week takes into account the large number of times that each reel is run through the projecting machine. The wear upon the film naturally is greater for the fifteen shows per day which this theater gives than it would be in a residence district show of four performances daily. It is true further that "first run" film is the most expensive run of film for the theater manager to buy, and that all of this theater's film is first run film.

The item of "sundry expenses" includes tickets, carbons, lamp renewals, machine repairs and depreciation, piano tuning, painting a large sign three times per week with each change of program, and many minor expenses.

In each of the items where the pay roll is involved, it is remembered that the item is doubled to provide for the two forces of employes covered by the list, the day force and the night force.

Six projection operators are employed, three for the day force and three for the night force; of each set of three, are two motion operators and one slide operator.

A guard in full police uniform is in attendance at the entrance door. A fire guard is required by the rules of the fire department of the city.

The orchestra of six employes comprises the two pianists, the two drummers, and the two sound artists.

Of the four singers, each is required to sing seven or eight times—a day's work. Two are on the day force and two on the night force; each sings once in each show.

WEEKLY EXPENSE SHEET

Rent and heat, per week	$923.00
Electricity, per week	200.00
Film rental	126.00
Song slides	2.00
Sundry expenses, per week	130.00
License	8.00
6 Projection operators	112.00
2 Cashiers	30.00
2 Uniformed police at door	36.00
2 Fire guards	28.00
2 Ticket takers	30.00
6 Orchestra and sound effects	210.00
4 Singers	100.00
3 Porters	36.00
8 Ushers	80.00
Manager, per week	40.00
Assistant manager, per week	25.00
Stenographer and bookkeeper	15.00
Messenger boy	6.00
Telephone	2.00
Office supplies and sundry	6.00
Average weekly expenses	$2,145.00

Average weekly receipts, $4,450.

Country Theater (1). The theater from which this expense sheet was taken was unsuccessful. The expense seems about a minimum for a theater in which the manager must employ help for all of his service, yet the gross receipts of the theater did not justify even this expense.

WEEKLY EXPENSE SHEET

Rent	$ 3.50
Film service, 7 reels weekly	18.00
Express charges	1.00
Electricity	3.00
Operator	10.00
Ticket seller	1.50
Pianist	3.00
Coal (winter expense)	2.00
Tickets, carbons and sundry	1.00
Total weekly expense	$43.00

Average weekly receipts, $40.

This town had a census population of 1,100 people, giving a probable weekly ticket window income of $27.50 to $55.

Country Theater (2). In the same town, under a different manager. The experience of the first theater had shown about what gross income could be expected. The expense account was planned to fall below the anticipated income by enough to leave a profit for the manager.

WEEKLY EXPENSE SHEET

Rent	$ 3.50
Film, eight reels, express paid	12.00
Electricity	3.00
Operator	......
Ticket seller	1.00
Pianist	2.50
Coal (winter expense)	2.00
Tickets, carbons and sundry	1.00
Newspaper advertisements	.50
Total weekly expense	$25.50

Average weekly receipts, $45.

The commercial run of film satisfied his audience for quality, and age of subject was immaterial, as all were new to his patrons. The eight reels were run as follows: Two on Monday night, one new and one holdover on Tuesday night; one new and one holdover Wednesday night; one new and one holdover Thursday night; one new and one holdover Friday night; two new reels and one holdover Saturday afternoon and Saturday evening. This gave a three-reel show on Saturday and prices of ten cents for adults and five cents for children were charged.

The manager ran the projecting machine himself, thus avoiding an expenditure for an operator's salary.

The ticket seller sold tickets and noted that the patrons dropped them into a ticket box at the door, which box could be seen by the manager from time to time as he chanced to look.

The pianist seems the only luxury on the bill of expense. The small advertisement in the local newspaper seems good business judgment.

Country Theater (3). In the same town, during the summer.

During this season, the patronage of the country folk is largely withdrawn except on Saturdays. The operation of the picture theater was changed to suit the changed conditions for the summer months.

The theater building or room was held over the summer at the uniform rental rate for the following winter's business. The film service was reduced to three reels for the Saturday show, and shows were given only on Saturday afternoon and evening. Admission was five and ten cents, as on Saturdays during the winter.

WEEKLY EXPENSE SHEET

Rent	$ 3.50
Film, three reels express paid	5.00
Electricity	1.00
Ticket seller	.25
Pianist	.75
Sundry expense	.50
Newspaper advertisements	1.00
Total weekly expense	$12.00

Receipts averaged between $15 and $20 weekly. In addition to the profit of the one day at the theater, the manager had other employment during the week.

Country Theater (4). This theater is located in a country town whose census population is but six hundred people. The gross income which might be expected in such a town, according to the rule, would be $15 to $30 per week, and this is based upon a show running six nights and one afternoon per week.

WEEKLY EXPENSE SHEET

Rent, heat and ticket seller, two days	$ 3.00
Film, five reels, two days	4.50
Express charges	.35
Expense for acetylene-lamp supplies	.30
Sundry expenses	1.00
Total weekly expense	$ 9.15

Average weekly receipts, $14.

For an exhibition room, a lodge hall seating about one hundred and twenty-five people was obtained at a price of two nights for $3, including the heating, and a ticket seller was furnished as a favor.

The item of film, five reels for $4.50, was attained by "splitting the week" with another theater in a neighboring town, which used the five reels during the remainder of the week.

The total expense of starting this theater was about $60 for a complete projecting outfit with acetylene lamp. Aside from this there was no expense but the curtain for the picture screen. The manager and operator was regularly employed during the day, his show profits being "velvet."

The program given was three reels the first night and two new reels and a selected holdover reel for the second night. The price was five cents.

Airdome. This name has been adopted to define a motion-picture theater in the open air. A fenced enclosure is chosen, or a canvas 8 to 10 feet high is erected upon stakes to form an enclosed yard. At one end a projection house or even a projection platform is built; at the other end, a picture screen of usual theater size is erected. Chairs are arranged before the screen as in any motion-picture theater, and the entire conduct of the airdome is quite the same. A platform may be built before the screen for vaudeville.

The airdome is for fair weather only. The novel idea seems to please the general public, whether the airdome is operated in a country town or upon a vacant lot in a large city.

The illustration, Fig. 5, shows an airdome upon a city lot

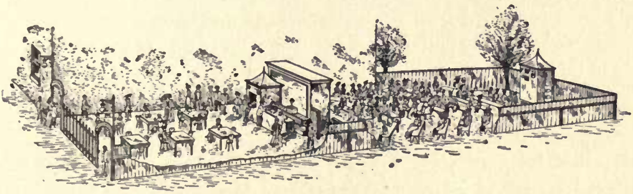


Fig. 5. The Airdome

beside a business house. The lot is divided by the picture screen and the admission gate, the front portion of the enclosure being used as a refreshment park in which the music from the airdome piano or orchestra (if any) is heard, while the rear portion of the lot is the theater itself.

OPERATION

Studying Audiences. The manager will learn much about his show by watching his patrons as they come out. It is not necessary to inquire what they think of the show Comments will pass among them which may be overheard by the manager and by the cashier as they pass the ticket window, commenting favorably and unfavorably upon the film pictures which they have seen a few minutes before. In this manner the manager may learn when any particular picture has favorable comment, and may endeavor to have his film exchange supply more of the same class; likewise, when any picture has a flood of unfavorable comment among the theatergoers themselves, the manager may try to influence his film exchange to avoid sending him that class of subject.

The words, "try to influence his film exchange," are chosen carefully to express the true position of the exhibitor, or theater manager, in the matter of obtaining film pictures acceptable to his patrons. The film exchanges as a rule take all the film pictures produced by the particular manufacturers from whom they buy. All of these film reels look alike to the film exchange man, and he would like to send them indiscriminately to his customers, to the exhibitors, or to theater managers. The service the theater manager will get, therefore, will be "hit or miss" of the film exchange stock of reels unless some influence is used by the manager to govern the classes of pictures furnished him. Film exchanges are notoriously lax in the matter of selecting pictures for particular theaters. If the film service is to be what the manager desires, the deliveries of the film exchange must be watched constantly and carefully.

The manager who has learned the tastes of his audience should consider their tastes as a requirement upon him to obtain the preferred classes of pictures from his film exchange. The responsiveness of the audience in the theater is one barometer of public approval; the attitude and conduct of patrons leaving the theater is another. The ticket sales will be another, but this last is not so quick in its indications of response.

When a picture pleases the audience, it may be the specific picture, or it may be the general class to which the picture belongs; in one neighborhood, dramatic and scenic may please more than comic or historical; in another nothing but comics can draw the crowds and send them away smiling.

The Program. Whether vaudeville is advisable and profitable, and whether the song is a drawing card or whether the audience would rather have solid pictures, all may be learned from watching the house during the performance and watching the faces and comments of the patrons as they pass out after seeing the performance.

Choice of a program is a great factor where the theater is in a competitive position. There is but little difference in expense between a three-reel program and two reels and a song.

Advertising. A sign at the door of the theater may announce the titles of the films being shown, or may announce merely that motion pictures are being shown. It is customary to announce the titles of the films if the films can be obtained from the film exchange

Fig. 6. A Title Poster

long enough in advance to prepare the sign, or if posters are delivered with the films. At times it may help business to advertise the name of the maker rather than the name of the film, or to post the announcement as to the nature of the picture, "A roaring farce tonight," or "Beautiful colored picture tonight," rather than a title which might not suggest the nature of the film. In all of these details of his announcement boards at the front of the theater, the manager must use his judgment as applied to his patrons. Variation in signs is advisable; and always bear in mind that the program, the film pictures, the song and the music, or vaudeville, if any, if mentioned in the theater-front signs, must justify the sign and fulfil all its promises.

Poster Service. Title posters may be obtained from the film exchanges at a very small cost—five cents each is the usual charge—or they may be obtained from companies making a specialty of supplying title posters for films. These come in one-sheet size—the standard title poster size adopted by all film makers—and have something the appearance of the poster of Fig. 6. The charge for a poster service consisting of a weekly shipment of posters for the current films, which the theater manager then holds until he gets the films and ultimately throws away the posters which he has received for which he never got the films, is from $5 to $10 per month.

In addition to simple "title posters" containing a stock form of border design (sometimes in color) and the title of the film printed upon it, the film manufacturers publish with each film an attractive colored poster, one-sheet size. A quantity of these are delivered to the film exchange with every film sold, and in turn the film exchange will furnish them to the exhibitor to whom the film is rented. As to the terms upon which the exhibitor may secure these posters, that is a matter individual to the film exchange. Usually they are furnished free to the customers who get the films first, paying the higher prices for the early runs of the film. Later users of the film do not get any posters because they are all gone. The "title poster" service is a resource when the manufacturer's more desirable picture posters cannot be obtained.

Electric Signs. An electric sign, with a word in letters formed by electric lamps, such as "Theater," "5c Theater," "Motion," or "Pictures," or even "5c," can be seen a long way up and down the street.

A simple electric sign is illustrated in Fig. 7. This has the words, "Theater 5c," in letters studded with electric lamps. With 4-candle-power lamps taking about 12 watts each, and with electric current at 10 cents per kilowatt, the cost of current for operating this sign four hours in an evening would be about fifty cents. To this may be added cost of lamp renewals, interest, and depreciation on the sign, if so desired. The cost of such a sign is about $50.

Another type of electric sign is shown in Fig. 8, in which the letters are not studded with lamps, but in which the lamps of the sign form the attractive feature. The figure *5c* in the middle of the sign is set with lamps, and the zigzag line from the upper right-hand corner to the lower left-hand corner is set with a line of lamps. A *sign flasher* is connected with this sign, lighting the lamps in this order: The zigzag line represents a lightning flash. The first lamp at the top is lighted, then the next, and so on until about eight are lighted, then as each lamp ahead is lighted the lamp earliest lighted of the eight is put out, so that the string of eight lamps seems to move along the zigzag line. This action is very rapid, and the lightning flash crosses the sign very quickly. Then the *5c* is lighted for a few seconds, then extinguished for a few seconds, and the lightning flash is repeated, beginning the next cycle. The flashing of the lamps is done by a drum of contacts run by a small motor. The number of lamps is about the same as in the sign of Fig. 7, and the cost of current is about the same, the lamps burning but a part of the time, and the motor running all the time. The first cost of the sign is much greater.

Fig. 7. A Simple Electric Sign

Fig. 8. Electric Sign with Flasher

In a simple sign bordered by lamps, the lamps may be made to "run around" in the same way that the flash crosses the sign of Fig. 8, adding to the attractiveness of an otherwise very plain sign.

Announcement Slides. The program of the theater always may be announced by advertising announcement slides. These take the form of "Pictures Changed Daily," "Song Changed Twice a Week," "New Song Tomorrow," "Colored Picture Tomorrow Night," "Special Educational Show for School Children, one hour, beginning at four o'clock Friday," all of which are direct advertising slides, but will not be so considered by the patrons because they pertain to the show. Although they take but a minute or two, they may well be omitted on Saturday night's rush, particularly if so doing will put on one more show in the evening.

"Next show" slides are of doubtful utility, announcing the subjects for tomorrow. It is doubtful whether at any time it is advisable to announce the subjects for tomorrow, if competitive theaters are near by, unless the subject is a special one and, therefore, specially advertised. When used, the "next show" slides must be prepared by the theater manager or projection operator, from day to day, as the titles are learned ahead.

Printed Programs. With "daylight pictures"—the expression is used to mean that the lights of the room are not turned off while the pictures are being shown—a printed program may be given to the patron at the door. The printed program always carries advertising matter, and should be so designed as to advertise the theater properly, as well as to serve its paid advertisers.

Newspapers. Advertisements inserted in the newspapers are seldom profitable in the large cities; in the smaller cities, it may be found so; but in the country town, where the newspaper is a weekly and everybody reads all of it, 50c or $1 per week is well spent. The simple announcement, with some display line in it, may or may not give the titles.

Handbills. In the large city, the theater located in the residence district will find that the handbill will take the place of the newspaper in the small town, and cost but little more. A thousand bills, 6 by 9 inches in size, may be had from the local printer for a price not to exceed $2, and a boy, at $1 for the afternoon, will deliver them. This expense should put a handbill into every residence within five blocks of the theater. Such a handbill should contain some special announcement as an excuse for its existence; the title and short mention of the nature of some special film to be featured will be sufficient excuse; or a prize voting contest, or special program of specific nature.

Noise Wagon. Painted banners are mounted on a wagon—sometimes called a "sandwich wagon"—and driven through the streets, a bell being hung inside which rings continually, or a drummer or bugler being carried. Its utility is limited. Days when the country people are in town form one excuse for this advertising device.

Feature Films. The manager should see the film himself before deciding to feature it. It may be seen at some other theater or at the film exchange; the film exchange will be able to tell the manager where the film is being shown, that he may go there to see it. The fact that a specific film is being advertised largely by its manufacturer is not sufficient basis for a manager to decide to feature it for his patrons, for such advertising may not be justified by the film, or even if so warranted, the film may have real merit and still not be suited to the tastes of the theater as the manager understands them.

Having selected a feature film, advertise it only a day ahead, both by theater-front signs and handbills. In addition, a printed program for the next night with the feature film advertised may be handed to patrons leaving the theater on the night before the feature is put on. Be careful that the word "Tomorrow" is prominent in the theater-front announcement which is posted a day ahead, or some patron, reading the sign carelessly, may go inside and be disappointed because he did not see the feature film mentioned for the next night.

Special Programs. An entire program made up of films of some specific nature may be called a special program, and advertised accordingly. "Biograph Night" on which nothing but biograph reels are used, might strike the popular fancy of some neighborhood, while "Travel Night" on which the majority of films are scenic, might "make a hit" with another neighborhood.

School Children. A special program of films particularly pleasing to children, and to some extent educational or travel, may be given in the afternoon after the close of school, and the result of the experiment noted. Special arrangements with the film exchange will be necessary, and a talk will be needed with the educational or travel films, otherwise they are usually too unfamiliar to the child mind and, therefore, dry and uninteresting.

Amateur Night. As a part of one show of the evening, amateurs are invited to entertain the audience, with a time limit of five minutes each; after all have done their acts, each walks upon the stage; each patron in the audience has been requested to decide upon the prize-winning act, and when the selected amateur enters the patrons favoring him applaud. The amateur getting the greatest applause is awarded the advertised prize of the evening. "Amateur Night" is usually made a weekly event in theaters where it is introduced.

Contests. This is merely a specialized "amateur night" in which all acts are limited to the same nature, thereby placing the several acts in direct contest with each other.

Double Price. A five-cent theater may run on Saturday night at a ten-cent admission fee. This not only increases the gross receipts for Saturday evening but acts as an advertising feature for the theater. A better show should be given, to justify the double price, in order that the patrons may not think the double price is being charged merely because the manager can get it on Saturday. The program, however, should not require double time, or there will be no gain by the double price. It may be slightly longer in time, and may have advertisable differences in quality if desired.

The live manager will find some excuse to make a special noise once in a while to get a few new patrons to come to his theater because of the special feature advertised.

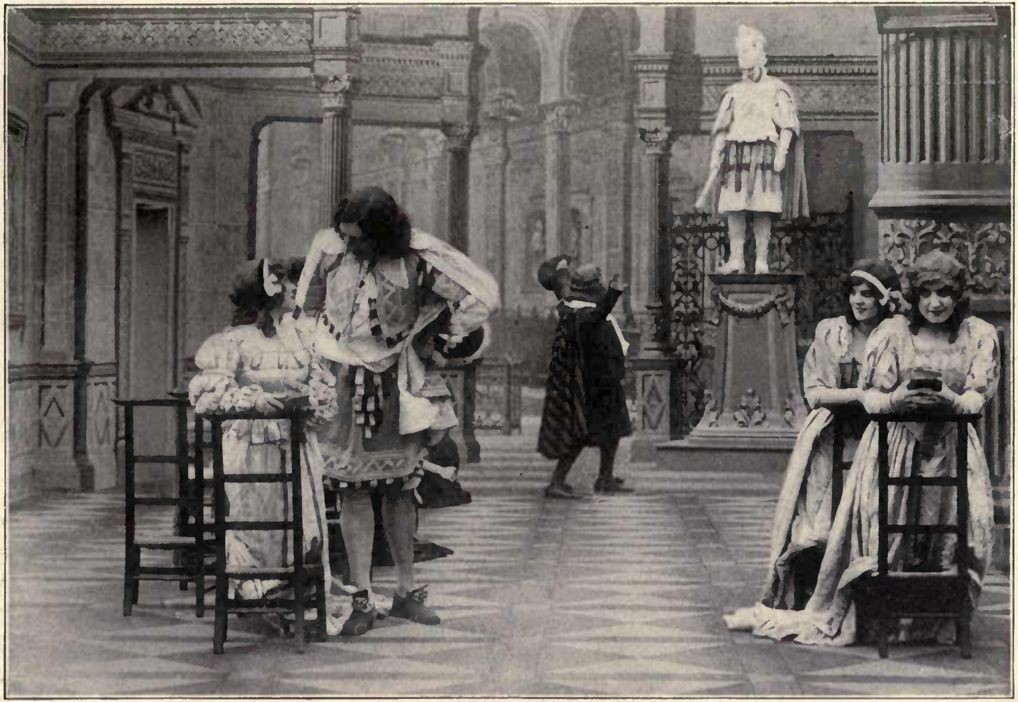
Renting Films. Subscribe for a magazine devoted to motion-picture interests, and read the advertisements of the film exchanges. Select two or three liberal advertisers near the theater and get their prices. Films contracted for as "not more than thirty days old" will be about the cheapest, quality considered. In the city, two reels, daily change, should cost $20 to $25 weekly. This is much better than "one reel ten days and one reel commercial," for "commercial" means "junk" to the exchange man. If you have film with a time limit, keep the file of the motion-picture magazine with its list of releases or clip and file the lists of releases and look up every film received to make sure that the exchange man is not giving you film older than your contract age. In a small town, the price to be paid for film will be limited by the gross income, and the manager must shop around the film exchanges to get the best he can for his money.

Get the benefit of competition among film exchanges by learning what others would charge for the service you are buying, but never change film exchanges without giving your own exchange a chance to meet the other fellow's prices and terms.

Song Slides. The slides are rented from the film exchange, although there are some exchanges handling song slides only. The price is 25 cents to $1 for the set of slides for a week or less, and extra for the sheet music if not returned with the slides.

Hiring Employes. In the cities, singer and pianist may be obtained in the neighborhood, by advertising in the daily papers or on the special program handbills. Either one should be em-

SCENE FROM PHOTOPLAY, "THE ROSE OF OLD ST. AUGUSTINE," OR "A TALE OF JEAN LAFITTE, THE PRIVATEER"
Courtesy of *Selig Polyscope Co., Inc., Chicago*



THE STATUE OF THE COMMANDER ACCEPTS DON JUAN'S INVITATION TO DINE
Scene from Photoplay, "Don Juan's Death"
Courtesy of *Eclair Film Co., Paris*

ployed at $1 to $1.50 per night. A drummer who is employed elsewhere during the day should have the same price. Cashier at $4 to $7 weekly is ample in the city. In the small towns, these prices may be cut one-half. The projection operator, with a license and a union in the city, must have $15 for evenings only. In the smaller towns, unless employed for the full day, he may be scheduled for one-half that price; this assumes that he is employed during the day elsewhere.

Automatic Music. An automatic piano may be rented or bought —$800 usually will buy one—and the perforated strip music may be obtained from a music exchange or "library" with daily or weekly charge at a price of $1 to $2.50 per month. The automatic piano may furnish the only music for an "all picture" show, or may be used early and late in the evenings to make the pianist's hours shorter and reduce the expense, besides being ready always to furnish music for a full evening when the pianist fails to appear.

Vaudeville. The acts must be booked from a dramatic booking agency; no other method is reliable nor satisfactory. A single act by a single actor may be put on at $25 per week and up. Any act will cost $25 per actor, and up from that price. If you are running vaudeville, by all means keep posted on what other theaters are doing, and get acquainted with their booking agencies, for competition's sake, to see that you are getting the best your money will buy.

Splitting the Week. Vaudeville is "weekly change." In the city, where the patronage of a residence district theater is limited to a small area, and in smaller cities, where a large proportion of patrons are likely to visit the theater oftener than one night in the week, the plan of "splitting the week" between two theaters is adopted to give each a change of vaudeville in the middle of the week. When two theaters are co-operating thus, films as well as vaudeville acts may be "split," particularly if the theaters are in two nearby country towns. Each theater hires a vaudeville act and a few reels of film for the week, and the entire program changes theaters in the middle of the week. Booking agencies will arrange for "split weeks" as desired.

Keeping Accounts. For theaters whose expenses and incomes run into hundreds of dollars weekly, a full double-entry set of books should be kept. For the smaller theaters, two books will answer the purpose very well. All theater accounts should be strictly cash. Since the ticket window account is strictly cash, there can be no good business policy in not having the expense account run on the same basis; if the cash from the income account will not pay cash for the expense account, quit the business or think of a good reason why not.

For a small theater, a little leather-covered pocket memorandum book may be used to write down all amounts paid out and received, for any purpose whatsoever. Memoranda of contracts and agreements may be entered in this book. The other book is a book of ruled pages, one for each week of the theater's operation; perhaps a book of fifty-two pages would be a convenient size, covering just a year of operation. The ruling of the pages of this book may be

	MO.	DAY	TITLE of FILMS	TITLE of SONGS	RECEIPTS		EXPENSES		
SUN.							RENT		
							ELECTRICITY		
MON.							FILM RENT		
							PIANO RENT		
TUES.							SLIDES		
							ADVERTISING		
WED.							EXPRESS		
							SALARY-OPERATOR		
THUR.							" SINGER		
							" PIANST		
FRI.							" TICKET SELLER		
							" DOOR KEEPER		
SAT.							" USHER		
							EXTRAS		
REMARKS:				ADMISSION RECEIPTS			TOTAL RECEIPTS		
				OTHER RECEIPTS			TOTAL EXPENSES		
				TOTAL RECEIPTS			NET PROFITS		

Fig. 9. Blank Form for Weekly Account of a Motion-Picture Theater

as shown in Fig. 9, or any modification of that form which suits the manager's fancy. A local printer would print a thousand of these on a good quality of letter paper for $4, and he would want about the same money for fifty-two of them, the principal labor being in the preparation of the printing form. By having them printed, the manager may have his own preferred ruling. Books answering the purpose may be bought for a year's business for a dollar or less.

Each day the titles of the films may be entered on the page. This is to prevent running the same film twice without a proper interval between, as might result from an error of the film exchange, or from a change in film exchanges. The songs are recorded likewise. Films and songs which seemed to be "hits" with the audience may be marked with a cross and asked for from the exchange as specials, "repeated by request" for advertising effect.

The ticket-window receipts and other receipts should be entered in the pocket memorandum book, and may be noted on the back of the weekly sheet until the end of the week, when the totals may be entered on the face of the weekly sheet, and the net profits for the week may be determined.

An extra sheet at the back of the book may have entered upon it in each space the total of the same space on all the weekly sheets. The net profits for the year thus may be shown, as well as a classification of the expenses for the year.

Dull Season. In summer-time in the country, the farmers are too busy to come to town except on Saturday afternoon. In summer-time in the city the people go to the parks or sit on their front porches. "In the good old summer-time," what is the picture-theater manager to do? If he worked hard during the winter, and expects to do the same next winter, it may be to his advantage ultimately to shut up the place for July and August, pay the rent on the vacant house, and take a thorough rest. A little painting and polishing may be done during this interval, and he can open the house with a big whoop and hurrah about September 1.

Another method is to make the show straight pictures, and cut the expense sheet to the absolute minimum; perhaps the ticket window will be able to get enough small coin to pay the operating charges. Nothing but a shopper's theater in the shopping center of a large city can run a summer show at winter profits. This excepts the picture show which is a part of a summer amusement park, and also the airdome. They are shows which flourish in the summer-time only.

A study of the weekly account sheets as summer approaches will show the dwindling profits. The manager then must decide what his policy for the summer will be.

Tickets and Chopper. Tickets will be furnished by the film exchanges at 15 to 20 cents per thousand, in rolls. They are sold by the cashier, and the proper amount of money which the cashier is to turn over to the manager may be determined by noting the number of the end ticket of the roll before the show and subtracting it from the end ticket of the roll after the show, multiplying the difference by the price of admission. This number of tickets should be found in the "ticket chopper," or ticket box, and also the numbers of the tickets in the box should correspond, if they were examined.

The ticket chopper takes its name from its function. It mutilates the ticket which is dropped into it in such manner that it may not be used again. Some choppers slit them into ribbons, while others punch holes in them, passing the tickets into one box and the small bits from the holes into another receptacle. In either case, the ticket if reclaimed from the box by fraud would not be suitable for use again. Where a ticket box which does not chop is used, the manager should give his personal attention to destroying the tickets each day, preferably by burning them. Every ticket that is not destroyed by the manager himself means a possible loss of five cents, for it might be used at the door again, even though its destruction is intrusted to another.

Change the color every day, having several rolls of different color, and using sometimes one and sometimes another. A ticket of the wrong color dropped into the ticket box will reveal an irregularity which may lead to important discoveries in the accounting system.

A quiet and accurate "head count" of people entering the theater door on an occasional night, compared with ticket numbers and cashier's receipts, will help to keep this most vital detail of the theater under control.

The manager sometimes is confronted with a class of patrons who stay in the theater longer than one show, and, therefore, longer than one admission fee justifies. When the house is "holding out" the crowds, each patron of this class reduces the profits of the theater. One method of handling this problem is to take tickets at the door until the first show begins; after that, do not take up the whole ticket, but tear off about one-quarter, permitting the patron to retain the large part of the ticket. This gives each patron entering during the show a torn ticket. Between shows, collect tickets from all in the theater. Those having no torn tickets must have seen the entire performance, and should pay another admission fee or leave the theater.

Side Lines for Profit. The patron has a sentiment against any form of advertising *in the theater.* For the theater in a competitive position, it is a good plan to avoid all semblance of advertising inside the theater—upon the walls or upon the picture screen, either drop curtain or lantern slides. The tone of the theater is improved by leaving the show clean and free from advertising of any kind, particularly if the competing theaters offer objectionable advertising matter. At the same time, the big vaudeville houses of the cities use their advertising drop curtain before the performance and put advertising matter in their street scenes. Also, the legitimate theaters sell candy in the auditorium between the acts and before the performance begins. The manager must judge his people on these points and handle his advertising accordingly.

Following are a few plans available for increasing the revenue of a theater beyond ticket-window receipts:

Wall Posters. This plan is borrowed from the street-car practice of assigning a wall space for advertising matter. The street-car practice is not objectionable, because the space is well chosen and advertising matter is confined strictly to the selected space. As to its application in any specific theater, the sentiment of the patrons must be judged. Many things will pass in a small country town which would not be endured by patrons in a city.

Advertising Drop Curtain. The picture screen is an unsightly object in the theater when there is no projected picture upon it. The appearance of the room is improved greatly during the intermission by lowering an ornamental drop curtain over the picture screen. This drop curtain may contain advertising matter. It should be well put on—at the expense of the advertising client—and a liberal price charged.

Advertising Slides. Advertising slides bear advertising matter for the advertising patron, and such slides are thrown upon the screen along with the set of announcement slides with which the program begins, before the motion pictures start. A single advertising slide is hardly objectionable anywhere, but too many will ruin the show.

In connection with advertising slides, insist that the slides be pleasing in appearance and brief in words. Of course the cost of making the slide is paid by the advertiser. Remember that the same people come to your theater every week, and insist upon a weekly change of the advertising slide also. The patron who comes the second time comes to see a different show. Not only the advertising slides of the paid advertiser must be changed often, but the announcement slides which are in substance advertising slides of the theater itself, must be changed. Old slides which have been on the shelf a few weeks may be "run" again as new from time to time, but change the slide program for the same reason that you change the picture program and the song program. Your people want something new all the time.

Don't let any patron get the thought that the manager is asleep or that the theater is not keeping up with every other theater in the land.

Program Advertising. This is a practice set by the large theaters. No theater program is complete without advertising matter upon it, and this can be obtained from local merchants at prices which will assist in paying the expense of printing the theater's program, or even yield a profit.

In soliciting program advertising, remember that the advertisement will increase the size and cost of the program, so that the price must be still greater than the difference in cost which the printer will make. The difference in cost may be learned by getting prices from the printer for the programs with and without advertising.

Handbills. The weekly handbill is worth its cost in any city show. The cost may be reduced by carrying the advertisement of a local merchant, or two or three in different lines of business, for a price in excess of the added cost of the bills at the printer's. In addition, a proportion of the distributing charge is added to the price for the merchant, always keeping the price to him lower than what it would cost him to print and distribute bills of his own.

Candy Kid. The practice of selling candy in theaters before and between acts is well established. Remember in this connection that the patrons come to the theater to be amused. The candy vendor can help much in their entertainment if his "act" is studied. One successful candy vendor waits only until the old crowd is out and then as soon as the new patrons start in he walks before the picture screen and says something like this: "I know, ladies and gentlemen, that you have come here tonight for a little fun, sport and amusement, and I am going to add to your fun just as much as I possibly can; I have tonight a package of —— candy which I am selling for five cents; as I pass up the aisle please have your change ready." He passes up the aisle with his basket as soon as the aisle is clear, selling candy and making remarks to entertain the crowd: "Don't be afraid to buy it; it's worth the money;" "The young man takes two packages because the young lady knows it's good;" "Every package guaranteed to send you home fat and happy;" "After you eat it, if you don't like it, give it back and I'll refund the nickel;" when the show starts before he has finished his trip, he says, "Keep your eyes on the pictures and hand me your money." Your people have come to your theater to be entertained; your candy vendor is making the intermission seem shorter and is positively adding to their entertainment.

Avoid the error of giving the candy vendor too much time. An intermission of eleven minutes has been observed and reported, "to allow the candy man to distribute his free samples, make a second tour of the audience to sell his confectionery, then a third tour to sell some songs." Not only will the audience resent the delay to the pictures, but the theater may actually lose money. When the house is running crowded, and patrons are waiting at the door, the number of tickets sold depends upon the speed with which those inside may be shown the entire program, that they may leave and make room for others. A 300-seat house, at 5-cent admission, running a 45-minute program, under crowded conditions, is making $15 for each program, or about 33 cents per minute while the pictures are on the screen. Assuming that the candy vendor will be able to sell fifty packages of candy at five cents each—a phenomenal sale for so small a house—and at a profit of two cents each to the theater, then for that $1 profit on the candy he is entitled to just three minutes' intermission.

To extend the intermission one minute is to lose more money at the ticket window than is made at the candy basket. When the theater manager understands this clearly, he will be in possession of a fundamental principle which applies to all other side lines for profit: *Only when the side line does not decrease the ticket window receipts, only when it leaves them unchanged or actually increases them, may it be considered as desirable or profitable.*

Slot Machines. The lobby, or entrance of the theater in front of the partition, offers space for a few compact automatic vending machines, if, in the manager's best judgment, such a plan is advisable. If the police regulations of the town will permit, an automatic vending machine may stand on the sidewalk at each side of the theater, just in the foot square of sidewalk space at the end of the theater's side walls.

Sheet Music Sales. It is a favor to many patrons to advise them where sheet music of the song may be obtained. An announcement slide, "The song on our program is always for sale at our ticket window," has no objection and does not seem advertising matter because it pertains to the theater.

Refreshment Annex. In the airdome, the refreshment business is so much associated with the motion-picture business, and they are so mutually helpful to each other that they usually are run in conjunction, each to boost the other. In the motion-picture winter theater, the relation cannot be so boldly emphasized or the departure from custom will be noted and adversely commented upon, but a candy store and soda fountain located near a motion-picture theater will do a larger business than if the theater were not there.

SCENE FROM "A PRIESTESS OF CARTHAGE," BY GAUMONT
Note the Careful Attention to Detail in Costumes, Architecture, and Foliage
Courtesy of the *Kleine Optical Co., Chicago*

SCENE FROM PHOTOPLAY, "THE LAST APPEAL"
Courtesy of *Independent Moving Pictures Co., New York*

ELECTRICAL PRINCIPLES

In the management of a motion-picture machine and theater the operator, even if he be well versed in the practical methods of running circuits for his machine, finds that he needs a knowledge of the elementary principles of electricity and some clear conception of how the electric current behaves in various types of circuits. It must be borne in mind, therefore, that only material deemed pertinent to the case has been included in this book. Those desiring more information are referred to any standard text.

ELECTRICITY IN MOTION—ELECTRICAL CURRENTS

Magnetic Effect Due to a Charge in Motion. An electrical charge at rest produces no magnetic effect whatever. This can be proved by bringing a charged body near a compass needle or suspended magnet. It will attract both ends equally well by virtue of the principle of electrostatic induction. If the effect were magnetic, one end should be repelled and the other attracted. Again, if a sheet of zinc, aluminum, or copper is inserted between the deflected needle and the charge, all effect which was produced upon the needle by the charge will be cut off, for the metallic sheet will act as an electric screen. But if such a metal screen is inserted between a compass needle and a magnet, its insertion has no effect at all on the magnetic forces.

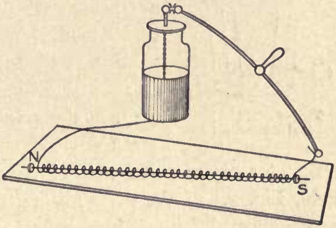


Fig. 1. Magnetic Effect of Electric Current

If, however, a charged Leyden jar is discharged through a coil which surrounds an unmagnetized knitting needle in the manner shown in Fig. 1, the needle will be found, after the discharge, to have become distinctly magnetized.

This experiment demonstrates the existence of some connection between electricity and magnetism. Just what this connection is, is not yet known with certainty; but it is known that *magnetic effects are always observable near the path of a moving electrical charge,* while no such effects can ever be observed near a charge at rest.

An electrical charge in motion is called an electrical current, and the presence of such current in a conductor is most commonly detected by the magnetic effect which it produces.

Galvanic Cell. When a Leyden jar is discharged, but a very small quantity of electricity passes through the connecting wires, since the current lasts but a small fraction of a second. If we could keep the current flowing continuously through the wire, we should expect the magnetic effect to be more pronounced. This might be done by discharging Leyden jars in rapid succession through the wire. In 1786, however, Galvani, an Italian anatomist at the University of Bologna, accidently discovered that there is a chemical method for producing such a continuous current. His discovery was not understood, however, until Volta, professor of physics at Como, devised an arrangement which is now known sometimes as the *voltaic,* sometimes as the *galvanic* cell.

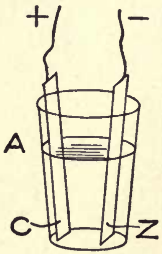


Fig. 2. Simple Galvanic Cells

Such a cell consists in its simplest form of a strip of copper and a strip of zinc immersed in dilute sulphuric acid, Fig. 2. If the wires leading from the copper and the zinc are connected for a few seconds to the end of the coil of Fig. 1, when an unmagnetized needle lies within this coil, the needle will be found to be much more strongly magnetized than it was when the Leyden jar was discharged through the coil. Or, if the wire connecting the copper and zinc is simply held above the needle in the manner shown in Fig. 3, the latter will be found to be strongly deflected. It is evident from these experiments that the wire which connects the terminals of a galvanic cell carries a current of electricity. Historically, the second of these experiments, performed by the Danish physicist Oersted in 1819, preceded the discovery of the magnetizing effect of currents upon needles. It created a great deal of excitement at the time because it was the first clew which had been found to a relationship between electricity and magnetism.

It might be inferred from the above experiments that the two plates of a galvanic cell when not connected by a wire carry static

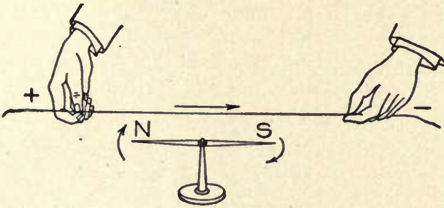


Fig. 3. Magnetic Effects of Current

positive and negative charges just as do the two coats of a Leyden jar before it is discharged through the wire. This inference can be easily verified with an electroscope.

Thus, if a metal plate *A*, Fig. 4, covered with shellac on its lower side and provided with an insulating handle, is placed upon a similar plate *B* which is in contact with the knob on an electroscope; and if the copper plate, for example, of a galvanic cell is connected to *A* and the zinc to *B;* then, when the connecting wires are removed and the plate *A* lifted away from *B*, the leaves of the electroscope will diverge and when tested will be found to be negatively charged. If the deflection observed in the leaves of the electroscope is too small for the purposes of demonstration, the conditions can be bettered by using a battery of from five to ten cells instead of the single cell. If, however, the plates *A* and *B* are sufficiently large—say, 3 or 4 inches in diameter—and if their surfaces are very flat, a single cell will be found to be sufficient. If, on the other hand, the copper plate is connected to *B* and the zinc to *A* in the above experiment, the elec-

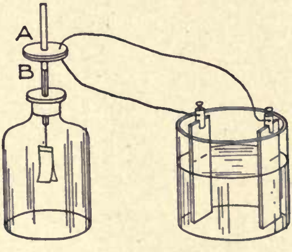


Fig. 4. Static Charges on Plates of Galvanic Cell

troscope will be found to be positively charged. This shows clearly that the copper plate possesses a positive electrical charge, while the zinc plate possesses a negative charge, these charges originating in the chemical action within the galvanic cell.

In this experiment the two metal plates separated by shellac constitute an electrical condenser which is charged positively on one side and negatively on the other by connecting it with the two plates of the galvanic cell, in precisely the same way in which a Leyden jar is charged by connecting its two coats one to one terminal and the other to the other terminal of a static machine. The potential of the plate *B* is increased by moving *A* away from it. This device makes it possible to detect very small potential differences.

Comparison of a Galvanic Cell and Static Machine. If one of the terminals of a galvanic cell is touched directly to the knob of the gold-leaf electroscope without the use of the condenser plates *A* and *B* of Fig. 4, no divergence of the leaves can be detected; but if one knob of a static machine in operation were so touched, the leaves would be thrown apart very violently. Since we have seen that the divergence of the leaves is a measure of the potential of the body to which they are connected, we learn from this experiment that the chemical actions going on in a galvanic cell are able to produce between its terminals but very small potential differences in comparison with that produced by the static machine between its terminals. As a matter of fact, the potential difference between the terminals of the cell is but one volt, while that between the terminals of an electrical machine may be several hundred thousand volts.

On the other hand, if the knobs of the static machine are connected to the ends of the wire shown in Fig. 3, and the machine operated, the current will not be large enough to produce any appreciable effect upon the needle. Since, under these same circumstances the galvanic cell produced a very large effect upon the needle, we learn that although the cell develops a much smaller p. d. than does the static machine, it nevertheless sends through the wire a very much larger amount of electricity per second. This means merely that the chemical actions which are going on within the cell are able to recharge the plates when they become discharged through the electric wire, far more rapidly than is the static machine able to recharge its terminals after they have once been discharged.

Shape of Magnetic Field about a Current. If we place the wire which connects the plates of a galvanic cell in a vertical position, Fig. 5, and explore with a compass needle the shape of the magnetic field about the current, we find that the magnetic lines are concentric circles lying in a plane perpendicular to the wire and having the wire as their common center. If we reverse the direction of the current, we find that the direction in which the compass needle points reverses also. If the current is very strong, say 40 amperes, this shape of the field can be shown by scattering iron filings on a plate through which the current passes, in the manner shown in Fig. 5.

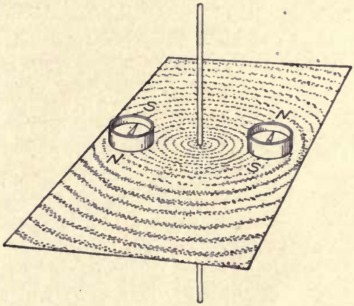


Fig. 5. Magnetic Field Around a Conductor

The relation between the direction in which the current flows and the direction in which the positive end of the needle points—this is by definition, the direction of the magnetic field—is given in the following rule: *If the right hand grasps the wire as in Fig. 6, so that the thumb points in the direction in which the positive electricity is moving, that is, in the direction from the copper toward the zinc, then the magnetic lines encircle the wire in the same direction as do*

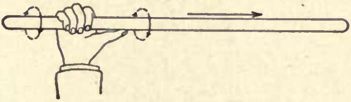


Fig. 6. Right-Hand Screw Rule for Direction of Magnetic Field

the fingers of the hand. Another way of stating this rule is as follows: *The relation between the direction of the current in a wire and the direction of the magnetic lines about it, is the same as the relation between the direction of the forward motion of a right-handed screw and the direction of rotation when it is being driven in.* In this form the rule is known as the *right-hand screw rule.*

Measurement of Electrical Currents. Electrical currents are, in general, measured by the strength of the magnetic effect which they are able to produce under specific conditions. Thus, if the wire carrying a current is wound into circular form as in Fig. 7, the right-hand screw rule shows us that the shape of the magnetic field at the center of the coil is similar to that shown in the figure. If, then, the coil is placed in a north-and-south plane and a compass needle is placed at the center, the passage of the current through the coil tends to deflect the needle so as to make it point east and west. The amount of deflection under these conditions is taken as the measure of current strength. The unit of current is called the *ampere* and is, in fact, approximately the same as the current which, flowing through a circular coil of three turns and 10 centimeters radius, set in a north-and-south plane, will produce at Washington

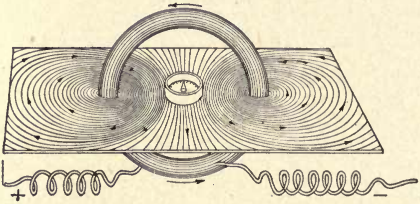


Fig. 7. Plotting Field About Circular Conductor

a deflection of 45 degrees in a small compass needle placed in its center, as in Fig. 7. Nearly all current-measuring instruments, commonly called *ammeters,* consist essentially either of a small magnet suspended at the center of a fixed coil as in Fig. 7, or of a movable coil suspended between the poles of a fixed magnet. The passage of the current through the coil produces a deflection, in the first case, of the magnetic needle with reference to the fixed coil, and in the second case, of the coil with reference to the fixed magnet. If the instrument has been suitably calibrated, the amount of the deflection gives at once the strength of the current in amperes.

Electromotive Force and Its Measurements. The potential difference which a galvanic cell or other generator of electricity is able to maintain between its terminals when these terminals are not connected by a wire, *i. e.*, the total electrical pressure which the

MARION RECEIVES THE NOTE
Scene from Pathé film. "Mistaken Identity"
Courtesy of *Pathé Frères, New York and Paris*

SCENE FROM PHOTOPLAY, "THE NIECE AND THE CHORUS LADY"
Courtesy of *Thomas A. Edison, Inc., Orange, N. J*

generator is capable of exerting, is commonly called its *electromotive force*, or *e. m. f. The e. m. f of an electrical generator may then be defined as its capacity for producing electrical pressure, or p. d.* This p. d. might be measured by the deflection produced in an electroscope, or other similar instrument, when one terminal was connected to the case of the electroscope and the other terminal to the knob. Potential differences are in fact measured in this way in all so-called electrostatic voltmeters, which are now coming more and more into use.

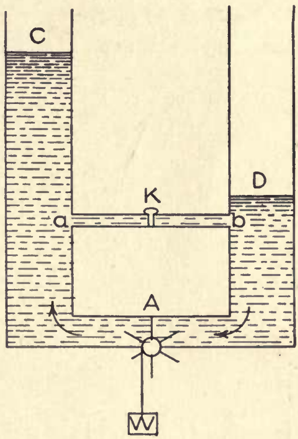


Fig. 8. Hydrostatic Analogy of Potential Difference

The more common type of potential difference measurers, so-called *voltmeters*, consists, however, of an instrument made like an ammeter, save that the coil of wire is made of an enormous number of turns of extremely fine wire, so that it carries at very small current. The amount of current which it does carry, however, and therefore the amount of deflection of its needle, is taken as proportional to the difference in electrical pressure existing between its ends when these are touched to the two points whose p. d. is sought. The principle underlying this type of voltmeter will be better understood from a consideration of the following water analogy. If the stopcock *K* Fig. 8, in the pipe connecting the water tanks *C* and *D* is closed, and if the water wheel *A* is set in motion by applying a weight *W*, the wheel will turn until it creates such a difference in the water levels between *C* and *D* that the back pressure against the left face of the wheel stops it and brings the weight *W* to rest. In precisely the same way, the chemical action within the galvanic cell whose terminals are not joined, Fig. 9, develops positive and negative charges upon these terminals, that is, creates a p. d. between them, until the back electrical pressure through the cell due to this p. d. is sufficient to put a stop to further chemical action.

Now, if the water reservoirs, Fig. 8, are put in communication by opening the stop-cock *K*, the difference in level between *C* and *D* will begin to fall, and the wheel will begin to build it up again. But if the carrying capacity of the pipe *a b* is small in comparison with the capacity of the wheel to remove water from *D* and to supply it to *C*, then the difference of level which permanently exists between *C* and *D* when *K* is open will not be appreciably smaller than when it is closed. In this case the current which flows through *AB* may obviously be taken as a measure of the difference in pressure which the pump is able to maintain between *C* and *D* when *K* is closed.

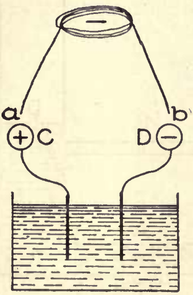


Fig. 9. Principle of Common Voltmeter

In precisely the same way, if the terminal *C* and *D* of the cell, Fig. 9, are connected by attaching to them the terminals *a* and *b* of any conductor, they at once begin to discharge through this conductor, and their p..d., therefore, begins to fall. But if the chemical action in the cell is able to recharge *C* and *D* very rapidly in comparison with the ability of the wire to discharge them, then the p. d. between *C* and *D* will not be appreciably lowered by the presence of the connecting conductor. In this case the current which flows through the conducting coil, and, therefore, the deflection of the needle at its center, may be taken as a measure of the electrical pressure developed by the cell, that is, of the p. d. between its unconnected terminals.

The common voltmeter is, then, exactly like an ammeter, save that its coil offers so high a resistance to the passage of electricity through it that it does not assist appreciably in discharging, that is, in reducing the p. d. between the points to which it is connected.

The unit of p. d. may be taken for practical purposes as the electrical pressure produced by a simple galvanic cell consisting of zinc and copper immersed in dilute sulphuric acid. It is named a *volt* in honor of Volta.

Electromotive Forces of Galvanic Cells. When a voltmeter of any sort is connected to the terminals of a galvanic cell, it is found that the deflection produced is altogether independent of the shape or size of the plates or their distance apart. But if the nature of the plates is changed, the deflection changes. Thus, while copper and zinc in dilute sulphuric acid have an e. m. f. of one volt, carbon and zinc show an e. m. f. of at least 1.5 volts, while carbon and copper will show an e. m. f. of very much less than a volt. Similarly, by changing the nature of the liquid in which the plates are immersed, we can produce changes in the deflection of the voltmeter. We learn, therefore, that *the e. m. f. of a galvanic cell depends simply upon the materials of which the cell is composed and not at all upon the shape, size, or distance apart of the plates.*

Electrical Resistance. If the terminals of a galvanic cell are connected first to, say, 10 feet of No. 30 copper wire, and then to 10 feet of No. 30 German-silver wire, it is found that a compass needle placed at a given distance from the copper wire will show a much larger deflection than when placed the same distance from the German-silver wire. A cell therefore, which is capable of developing a certain fixed electrical pressure is able to force very much more current through a given wire of copper than through an exactly similar wire of German-silver. We say, therefore, that German-silver offers a higher *resistance* to the passage of electricity than does copper. Similarly, every particular substance has its own characteristic power of transmitting electrical currents. Silver being the best conductor of any known substances, the resistances of different substances are commonly referred to silver as a standard, and the ratio between the resistance of a given wire of any substance and the resistance of an exactly similar silver wire is called the *specific resistance* of that substance. The specific resistance of some of the commoner metals are as follows:

Silver	1.00	Soft iron	7.40	German silver	20.4
Copper	1.13	Nickel	7.87	Hard steel	21.0
Aluminum	2.00	Platinum	9.00	Mercury	62.7

The unit of resistance is the resistance of 0° of a column of mercury 106.3 centimeters long and 1 square millimeter in cross-section. It is called an *ohm*, in honor of the great German physicist, Georg Ohm (1789-1854). A length of 9.35 feet of No. 30 copper wire, or 6.2 inches of No. 30 German-silver wire, has a resistance of about one ohm. Copper wire of the size shown in Fig. 10 has a resistance of about 2.62 ohms per mile.

The resistances of all metals increase with rise in temperature. The resistances of liquid conductors, on the other hand, usually decrease with rise in temperature. Carbon and a few other solids show a similar behavior: the filament in an incandescent lamp has only about half the resistance when hot that it has when cold. The resistances of wires of the same material are found to be directly proportional to their lengths, and inversely proportional to their cross-sections.

Fig. 10. Exact Size of No. 7 Copper Wire

Ohm's Law. In 1827, Ohm announced the discovery that *the currents furnished by different galvanic cells, or combinations of cells, are always directly proportional to the e. m. f.'s existing in the circuits in which the currents flow, and inversely proportional to the total resistances of these circuits;* that is, if C represents the current in amperes, E the e. m. f. in volts, and R the resistance of the circuit in ohms, then Ohm's law as applied to the complete circuit is

$$C=\frac{E}{R};\ i.\ e.,\ current=\frac{electromotive\ force}{resistance}$$

As applied to any portion of an electrical circuit, Ohm's law is

$$C=\frac{pd}{r};\ i.\ e.,\ current=\frac{potential\ difference}{resistance}$$

where pd represents the difference of potential in volts between any two points in the circuit, and r the resistance in ohms of the conductor connecting these two points. This is one of the most important laws in physics.

Both of the above statements of Ohm's law are included in the equation

$$amperes=\frac{ohms}{volts}$$

Internal Resistance of a Galvanic Cell. If the zinc and copper plates of a simple cell are connected to an ammeter, and the distance between the plates then increased, the deflection of the needle is found to decrease, or if the amount of immersion is decreased the current also will decrease. But since the e. m. f. of a cell has been shown to be wholly independent of the area of the plates immersed or of the distance between them, it will be seen from Ohm's law that the change in the current in these cases must be due to some change in the total resistance of the circuit. Since the wire which constitutes the outside portion of the circuit has remained the same, we must conclude that *the liquid within the cell, as well as the external wire, offers resistance to the passage of the current.* This internal resistance of the liquid is directly proportional to the distance between the plates, and inversely proportional to the area of the immersed portion of the plates. If, then, we represent the external resistance of the circuit of a galvanic cell by R_e and the internal by R_i then Ohm's law as applied to the entire circuit takes the form

$$C=\frac{E}{R_e+R_i}$$

Thus, if a simple cell has an internal resistance of 2 ohms and an e. m. f. of 1 volt, the current which will flow through the circuit when its terminals are connected by 9.3 feet of No. 30 copper wire (1 ohm) is $\frac{1}{1+2}=$ 33 ampere. This is about the current which is usually obtained from an ordinary Daniell cell.

PRIMARY CELLS

Action of a Simple Cell. If the simple cell already mentioned —namely, zinc and copper strips in dilute sulphuric acid—is carefully observed, it will be seen that, so long as the plates are not connected by a conductor, fine bubbles of gas are slowly formed at the zinc plate, but none at the copper plate. As soon, however, as the two strips are put into electrical connection, bubbles instantly appear in great numbers about the copper plate and at the same time a current manifests itself in the connecting wire, Fig. 11. The bubbles are of hydrogen. Their original appearance on the zinc plate may be prevented either by using a plate of chemically pure zinc, or by amalgamating impure zinc, that is, by coating it over with a thin film of mercury. But the bubbles on the copper cannot be thus disposed of. They are an invariable accompaniment of the current in the circuit. If the current is allowed to run for a considerable time, it will be found that the zinc wastes away, even though it has been amalgamated, but the copper plate does not undergo any change.

An electrical current in a simple cell is, then, accompanied by the eating up of the zinc plate by the liquid, and by the evolution of hydrogen bubbles at the copper plate. In every type of galvanic cell, actions similar to these two are always found, that is, *one of the plates is always eaten up, and on the other some element is deposited.* The plate which is eaten is always the one which is found to be negatively charged, while the other is always found to be positively charged; so that in all galvanic cells, when the terminals are connected through a wire, the positive electricity flows through this wire from the uneaten plate to the eaten plate. It will be remembered that the direction in which the *positive* electricity flows is taken for convenience as the direction of the current.

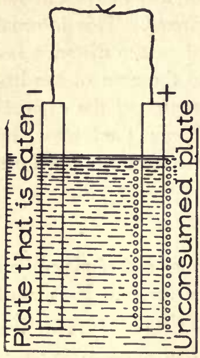


Fig. 11. Action of a Simple Cell

Theory of Action of a Simple Cell. A simple cell may be made of any two dissimilar metals immersed in a solution of any acid or salt. For simplicity, let us examine the action of a cell composed of plates of zinc and copper immersed in a dilute solution of hydrochloric acid. The chemical formula for hydrochloric acid is HCl. This means that each molecule of the acid consists of one atom of hydrogen combined with one atom of chlorine. In accordance with the theory now in vogue among physicists and chemists, when hydrochloric acid is mixed with water so as to form a dilute solution, the HCl molecules split up into two electrically charged parts, called *ions,* the hydrogen ion carrying a positive charge and the chlorine ion an equal negative charge, Fig. 12. This phenomenon is known as *dissociation.* The solution as a whole is neutral, *i. e.,* it is uncharged, because it contains just as many positive as negative ions.

When a zinc plate is placed in such a solution, the acid attacks it and pulls zinc atoms into solution. Now, whenever a metal dissolves in an acid, its atoms, for some unknown reason, go into solution bearing little positive charges. *The corresponding negative charges must be left on the zinc plate* in precisely the same way in which a negative charge is left on silk when positive electrification is produced on a glass rod by rubbing it with the silk. It is in this way, then, that we attempt to account for the negative charge which we find upon the zinc plate in the experiment illustrated in Fig. 4.

The passage of positively charged zinc ions into solution gives a positive charge to the solution about the zinc plate, so that the hydrogen ions tend to be repelled toward the copper plate. When these repelled hydrogen ions reach the copper plate some of them give up their charges to it and then collect as bubbles of hydrogen gas. It is in this way that we account for the positive charge which we find on the copper plate in the experiment illustrated in Fig. 4.

If the zinc and copper plates are not connected by an outside conductor, this passage of positively charged zinc ions into solution continues but a very short time, for the zinc soon becomes so strongly charged negatively that it pulls back on the plus zinc ions with as much force as the acid pulls them into solution. In precisely the same way the copper plate soon ceases to take up any more positive electricity from the hydrogen ions, since it soon acquires a large enough plus charge to repel them from itself with a force equal to that with which they are being driven out of solution by the positively charged zinc ions. It is in this way that we account for the fact that on open circuit no chemical action goes on in the simple galvanic cell, the zinc and copper plates simply becoming charged to a definite difference of potential which is called the e. m. f. of the cell.

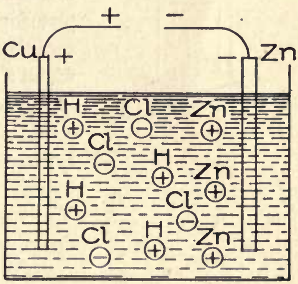


Fig. 12. Dissociation of Ions in Simple Cell

When, however, the copper and zinc plates are connected by a wire, a current at once flows from the copper to the zinc, and the plates thus begin to lose their charges. This allows the acid to pull more zinc into solution at the zinc plate, and allows more hydrogen to go out of solution at the copper plate. These processes, therefore, go on continuously so long as the plates are connected. Hence, a continuous current flows through the connecting wire until the zinc is all eaten up or the hydrogen ions have all been driven out of the solution, *i. e.*, until either the plate or the acid has become exhausted.

Polarization. If the simple cell, which has been described, is connected to an ammeter and the deflection observed for a few minutes, it is found to produce a current of continually decreasing strength; but if the hydrogen is removed from the copper plate by taking out the plate and drying it, the deflection returns to its first value. This phenomenon is called *polarization*.

The presence of the hydrogen on the positive plate causes a diminution in the strength of the current for two reasons: *First*, since hydrogen is a non-conductor, by collecting on the plate it diminishes the effective area of the plate and, therefore, increases the internal resistance of the cell; *second*, by collecting upon the copper plate it lowers the e. m. f. of the cell, because it virtually substitutes a hydrogen plate for the copper plate, and we have already seen that a change in any of the materials of which a cell is composed changes its e. m. f.

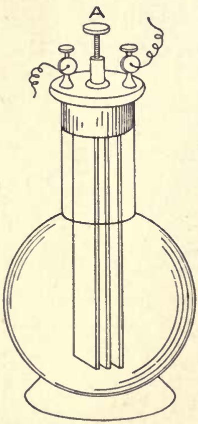


Fig. 13. Bichromate Cell

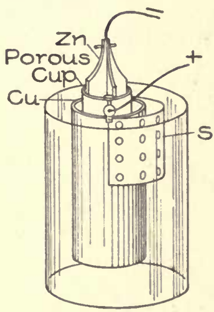
The different forms of galvanic cells in common use differ chiefly in different devices employed either for disposing of the hydrogen bubbles or for preventing their formation. The most common types of such cells are described in the following sections.

Bichromatic Cell. The bichromate cell, Fig. 13, consists of a plate of zinc immersed in sulphuric acid between two plates of carbon, carbon being used instead of copper because it gives a greater e. m. f. In the sulphuric acid is dissolved some bichromate of potassium or sodium, the function of which is to unite chemically with the hydrogen as fast as it is formed at the positive plate, thus preventing its accumulation upon this plate.* Such a cell has the high e. m. f. of 2.1 volts. Its internal resistance is low—from .2 to .5 ohm—since the plates are generally large and close together. It will be seen, therefore, that when the external resistance is very small it is capable of furnishing a current of from 5 to 10 amperes. Since, however, the chromic acid formed by the union of the sulphuric acid with the bi-

*To set up a bichromate cell, dissolve 12 parts, by weight, of sodium bichromate in 180 parts of boiling water. After cooling, add 25 parts of commercial sulphuric acid.

chromate attacks the zinc even when the circuit is open, it is necessary to lift the zinc from the liquid by the rod *A*, when the cell is not in use. Such cells are useful where large currents are needed for a short time. The great disadvantages are that the fluid deteriorates rapidly, and that the zinc cannot be left in the liquid.

Daniell Cell. The Daniell cell consists of a zinc plate immersed in zinc sulphate, and a copper plate immersed in copper sulphate, the two liquids being kept apart either by means of a porous earthen cup, as in the types shown in Fig. 14, or else by gravity, as in the type shown in Fig. 15. This last type, commonly called the *gravity,* or



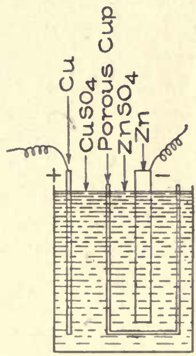


Fig. 14. Section of Daniell Cell   Daniell Cell (Commercial Type)

crowfoot type, is used almost exclusively on telegraph lines. The copper sulphate, being the heavier of the two liquids, remains at the bottom about the copper plate, while the zinc sulphate remains at the top about the zinc plate.

In this cell polarization is almost entirely avoided, for the reason that no opportunity is given for the formation of hydrogen bubbles. For, just as the hydrochloric acid solution consists of positive hydrogen ions and negative chloride ions in water, so the zinc sulphate ($ZnSO_4$) solution consists of positive zinc ions and negative SO_4 ions. Now the zinc of the zinc plate goes into solution in the zinc sulphate in precisely the same way that it goes into solution in the hydrochloric acid of the simple cell. This gives a positive charge to the solution about the zinc plate, and causes a movement of the positive ions between the two plates from the zinc toward the copper, and of negative ions in the opposite direction, both the Zn and the SO_4 ions being able to pass through the porous cup. Since the positive ions about the copper plate consist of atoms of copper, it will be seen that the material which is driven out of solution at the copper plate, instead of being hydrogen, as in the simple cell, is metallic copper. Since, then, the element which is deposited on the copper plate is of the same molecular structure as that of which it already consists, it is clear that neither the electromotive force nor the resistance of the cell can be changed by the presence of this deposit, *i. e.*, the cause of the polarization of the simple cell has been removed.

The great advantage of the Daniell cell lies in the relatively high degree of constancy in its e. m. f. (1.08 volts). It has a comparatively high internal resistance—one to six ohms—and is, therefore, incapable of producing very large currents, about one ampere at most. It will furnish a very constant current, however, for a great length of time; in fact until all of the copper is driven out of the copper sulphate solution. In order to keep a constant supply of the copper ions in the solution, copper sulphate crystals are kept in the compartment *S* of the cell of Fig. 14, or in the bottom of the gravity cell. These dissolve as fast as the solution loses its strength through the deposition of copper on the copper plate.

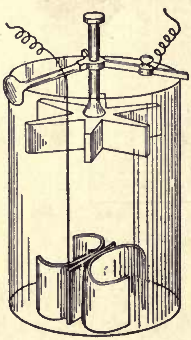


Fig. 15. Gravity Cell

The Daniell is a so-called *closed-circuit* cell, *i. e.*, its circuit should be left closed—through a resistance of thirty or forty ohms—whenever the cell is not in use. If it is left on open circuit, the copper sulphate diffuses through the porous cup, and a brownish muddy deposit of copper or copper oxide is formed upon the zinc. Pure copper is also deposited in the pores of the porous cup. Both of these actions damage the cell. When the circuit is closed, however, since the electrical forces always keep the copper ions moving toward the copper plate, these damaging effects are to a large extent avoided

Leclanché Cell. The Leclanché cell, Fig. 16, consists of a zinc rod in a solution of ammonium chloride—150 g. to a liter of water—and a carbon plate placed inside of a porous cup which is packed full of manganese dioxide and powdered graphite or carbon. As in the simple cell, the zinc dissolves in the liquid, and hydrogen is liberated at the carbon, or positive, plate. Here it is slowly attacked by the manganese dioxide. This chemical action is, however, not quick enough to prevent rapid polarization when large currents are taken from the cell. The cell slowly recovers when allowed to stand for a while on open circuit. The e. m. f. of a Leclanché cell is about 1.5 volts, and its initial internal resistance is somewhat less than an ohm. It, therefore, furnishes a momentary current of from one to three amperes.

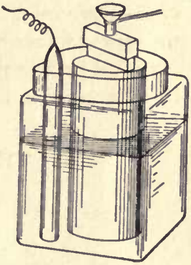


Fig. 16. Leclanché Cell

The immense advantage of this type of cell lies in the fact that the zinc is not at all eaten by the ammonium chloride when the circuit is open, and that, therefore, unlike the Daniell or bichromate cells, it can be left for an indefinite time on open circuit without deterioration. Leclanché cells are used almost exclusively where momentary currents only are needed, as, for example, on door-bell circuits. The cell requires no attention for years at a time, other than the occasional addition of water to replace loss by evaporation, and the occasional addition of ammonium chloride (NH_4Cl) to keep positive NH_4 and negative Cl ions in the solution.

Dry Cell. The dry cell is only a modified form of the Leclanché cell. It is not really *dry*, since the zinc and carbon plates are imbedded in moist paste which consists usually of one part of crystals of ammonium chloride, three parts of plaster of Paris, one part of zinc oxide, one part of zinc chloride, and two parts of water. The plaster of Paris is necessary in order to give the paste the required rigidity. As in the Leclanché cell, the current is produced by the chemical action of the ammonium chloride upon the zinc plate which forms the outside wall of the cell.

Combinations of Cells. There are two ways in which cells may be combined: *First,* in series; and *second,* in parallel. When they are connected in series the zinc of one cell is joined to the copper of the second, the zinc of the second to the copper of the third, etc., the copper of the first and the zinc of the last being joined to the ends of the external resistance, Fig. 17. The e. m. f. of such a combination is the sum of the e. m. f.'s of the single cells. The internal resistance of the combination is also the sum of the internal resistances of the single cells. Hence, if the external resistances are very small, the current furnished by the combination will not be larger than that furnished by a single cell, since the total resistance of the circuit has been increased in the same ratio as the total e. m. f. But if the ex-

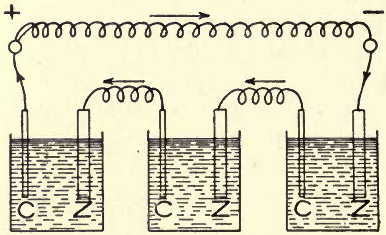


Fig. 17. Cells Connected in Series

ternal resistance is large, the current produced by the combination will be very much greater than that produced by a single cell. Just how much greater can always be determined by applying Ohm's law, for if there are n cells in series, and E is the e. m. f. of each cell, the total e. m. f. of the circuit is $n\,E$. Hence if R_e is the external resistance and R_i the internal resistance of a single cell, then Ohm's law gives

$$C = \frac{nE}{R_e + nR_i}$$

If the n cells are connected in parallel, that is, if all the coppers are connected together and all the zincs, as in Fig. 18, the e. m. f. of the combination is only the e. m. f. of a single cell, while the internal resistance is $\frac{1}{n}$ of that of a single cell, since connecting the cells in this way is simply equivalent to multiplying the area of the plates n times. The current furnished by such a combination will be given by the formula

$$C = \frac{E}{R_e + \frac{R_i}{n}}$$

If, therefore, R_e is negligibly small, as in the case of a heavy copper wire, the current flowing through it will be n times as great as that which could be made to flow through it by a single cell. These considerations show that the rules which should govern the combination of cells are as follows:

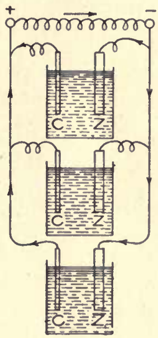


Fig. 18. Cells Connected in Parallel

When the external resistance is large in comparison with the internal resistance of a single cell, the cells should be connected in series.

When the external resistance is small in comparison with the internal resistance of a single cell, the cells should be connected in parallel.

Storage Battery. If two lead plates are immersed in sulphuric acid and the current sent through the cell, the anode or plate at which the current enters the solution will be found in the course of a few minutes to turn dark brown. This brown coat is a compound of lead with the oxygen which, in the case of the platinum electrodes, was evolved as a gas. The other lead plate is not affected by the hydrogen, which is, in this case, as in that of the platinum, evolved as a gas. Since the passage of the current through this cell has left one plate unchanged, while it has changed the surface of the other plate to a new substance, namely, lead peroxide, PbO_2, it might be expected that if the charging battery were removed, and these two dissimilar plates connected with a wire, a current will flow through the wire, for the arrangement is now essentially a simple galvanic cell, which in its essentials consists simply of two dissimilar plates immersed in an electrolyte—a conducting liquid other than a molten metal. In this case the plate having the lead peroxide upon it corresponds to the copper of an ordinary cell, and the unchanged lead plate to the zinc. The arrangement will furnish a current until the lead peroxide is all used up. The only important difference between a commercial storage cell and the two lead plates just considered, is that the former is provided in the process of manufacture with a very much thicker coat of the *active material*—lead peroxide on the positive plate, and a porous, spongy lead on the negative—than can be formed by a single charging such as we considered. In one type of storage cell this active material is actually formed by the repeated charging and discharging of plates which are originally ordinary sheets of lead. With each new charging a slightly thicker layer of the lead peroxide is formed. In the more common type of commercial cell the active material is pressed into interstices of the plate in the form of a paste. It will be seen from this discussion that a storage battery is not, properly speaking, a device for storing electricity. It is rather a device in which the electrical current produces chemical changes, and these new chemicals, so long as they last, are capable of generating a new electrical current.

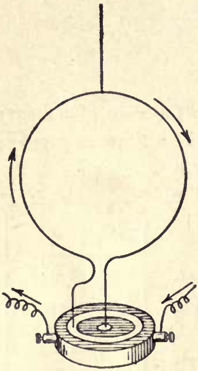


Fig. 19. Magnetic Properties of a Loop

ELECTROMAGNETISM

Magnetic Properties of a Loop. We have seen that an electrical current is surrounded by a magnetic field the direction of which is given by the right-hand rule. We have seen also that a loop or coil of wire through which a current flows produces a magnetic field of the shape shown in Fig. 7. Now, if such a loop is suspended in the manner shown in Fig. 19 while a current is passed through it, it is found to slowly set itself in an east-and-west plane, and so that the face of the loop from which the magnetic lines emerge, Fig. 20, is toward the north. In other words, the loop will be found to behave with respect

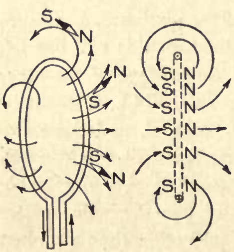


Fig. 20. Magnetic Properties of a Loop

to the earth or to any other magnet precisely as though it were a flat magnetic disk whose boundary is the wire, the face which turns toward the north, that is, that from which the magnetic lines emerge, being an N pole and the other an S pole.

Magnetic Properties of a Helix. If a wire carrying a current be wound in the form of a helix and held near a suspended magnet

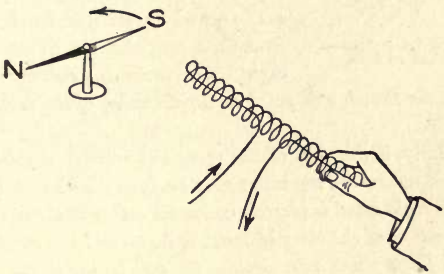


Fig. 21. Magnetic Properties of a Helix

as in Fig. 21, the coil will be found to act in every respect like a magnet, with an N pole at one end and an S pole at the other.

This result might have been predicted from the fact that a single loop is equivalent to a flat-disk magnet. For when a series of such disks is placed side by side, as in the helix, the result must be the

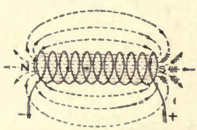


Fig. 22. Magnetic Field About a Helix

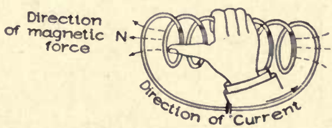


Fig. 23. Right-Hand Rule for a Helix

same as placing a series of disk magnets in a row, the N pole of one being directly in contact with the S pole of the next, etc. These poles would, therefore, all neutralize each other except at the two ends. We, therefore, get a magnetic field of the shape shown in Fig. 22, the direction of the arrows representing as usual the direction in which an N pole tends to move.

Rules for North and South Poles of a Helix. The right-hand rule as already given is sufficient in every case to determine which is the N and which the S pole of a helix, *i. e.*, from which end the lines of magnetic force emerge from the helix and at which end they enter it. But it is found convenient, in the consideration of coils, to restate the right-hand rule in a slightly different way, Fig. 23, thus:

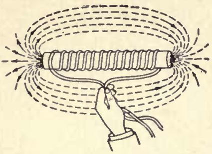


Fig. 24. A Simple Electromagnet and Its Field

If the coil is grasped in the right hand in such a way that the fingers point in the direction in which the current is flowing in the wires, the thumb will point in the direction of the north pole of the helix.

Similarly, if the sign of the poles is known, but the direction of the current unknown, the latter may be determined as follows:

If the right hand is placed against the coil with the thumb pointing in the direction of the lines of force, i. e., toward the north pole of the helix, the fingers will pass around the coil in the direction in which the current is flowing.

Electromagnet. If a core of soft iron be inserted in the helix, Fig. 24, the poles will be found to be enormously stronger than before. This is because the core is magnetized by induction from the field of the helix in precisely the same way in which it would be magnetized by induction if placed in the field of a permanent magnet. The new field strength about the coil is now the sum of the fields due to the core and that due to the coil. If the current is broken, the core will at once lose the greater part of its magnetism. If the current is re-

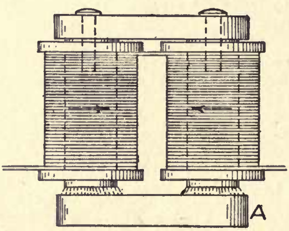


Fig. 25. Horseshoe Electromagnet with Armature

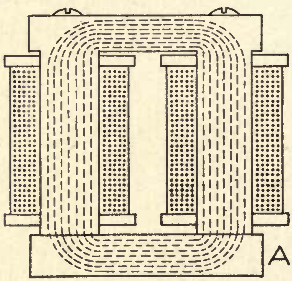


Fig. 26. Field of Horseshoe Electromagnet

SCENE FROM "POEMS IN PICTURES," BY GAUMONT
A Series of Imaginative Conceptions Which Deeply Impressed the Artistic Element of the Country
Courtesy of the *Kleine Optical Co., Chicago*

THE PRINCE FINDS LITTLE SNOWWHITE
Scene from Pathé film, "Little Snowwhite"
Courtesy of *Pathé Frères, New York and Paris*

versed, the polarity of the core will be reversed. Such a coil with a soft-iron core is called an *electromagnet.*

The strength of an electromagnet can be very greatly increased by giving it such form that the magnetic lines can remain in iron throughout their entire length instead of emerging into air, as they do in Fig. 24. For this reason electromagnets are usually built in the horseshoe form and provided with an armature *A*, Fig. 25, through which a complete iron path for the lines of force is established as shown in Fig. 26. The strength of such a magnet depends

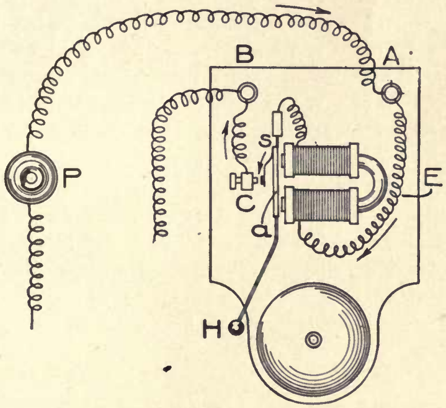


Fig. 27. Simple Electric Bell and Connections

chiefly upon the number of *ampere-turns* which encircle it, the expression *ampere-turns* denoting the product of the number of turns of wire about the magnet by the number of amperes flowing in each turn. Thus a current of $\frac{1}{100}$ ampere flowing 1,000 times around a core will make an electromagnet of precisely the same strength as a current of 1 ampere flowing 10 times about the core.

Electric Bell. The electric bell, Fig. 27, is one of the simplest applications of the electromagnet. When the button *P* is pressed, the electric circuit of the battery is closed and a current flows in at *A*, through the magnet, over the closed contact *C*, and out again at *B*. But no sooner is this current established than the electromagnet *E* pulls over the armature *a*, and in so doing breaks the contact at *C*.

This stops the current and demagnetizes the magnet *E*. The armature is then thrown back against *C* by the elasticity of the spring *s* which supports it. No sooner is the contact made at *C* than the current again begins to flow and the former operation is repeated. Thus the circuit is automatically made and broken at *C* and the hammer *H* is, in consequence, set into rapid vibration against the rim of the bell.

LAWS OF CURRENT FLOW

RESISTANCE

All substances resist the passage of electricity, but the resistance offered by some is very much greater than that offered by others. Metals have by far the least resistance and, of these, silver possesses the least of any. In other words, silver is the best conductor. If the temperature remains the same, the resistance of a conductor is not affected by the current passing through it. A current of ten, twenty, or any number of amperes may pass through a circuit, but its resistance will be unchanged with constant temperature. Resistance is affected by the temperature and also by the degree of hardness. Annealing decreases the resistance of a metal.

Conductance. Conductance is the inverse of resistance, that is, if a conductor has a resistance of R ohms, its conductance is equal to $\frac{1}{R}$.

Resistance Proportional to Length. The resistance of a conductor is directly proportional to its length. Hence, if the length of a conductor is doubled, the resistance is doubled, or if the length is divided, say into three equal parts, then the resistance of each part is one-third the total resistance.

EXAMPLE. The resistance of 1,283 feet of a certain wire is 6.9 ohms. What is the resistance of 142 feet of the same wire?

Solution. As the resistance is directly proportional to the length we have the proportion

$$\textit{required resistance} : 6.9 :: 142 : 1283$$

or,

$$\frac{\textit{required resistance}}{6.9} = \frac{142}{1283}$$

Hence,

$$\textit{required resistance} = 6.9 \times \frac{142}{1283}$$

$$= .76 \text{ ohm (approx.)}$$

Ans. .76 ohm.

EXAMPLE. The resistance of a wire having a length of 521 feet is .11 ohm. What length of the same wire will have a resistance of .18 ohm?

Solution. As the resistance is proportional to length, we have the proportion

$$\textit{required length} : 521 :: .18 : .11$$

or,

$$\frac{\textit{required length}}{521} = \frac{.18}{.11}$$

Hence,

$$\textit{required length} = 521 \times \frac{.18}{.11}$$

$$= 852 \text{ feet (approx.)}$$

Ans. 852 feet.

Resistance Inversely Proportional to Cross-Section. The resistance of a conductor is inversely proportional to its cross-sectional area. Hence the greater the cross-section of a wire the less is its resistance. Therefore, if two wires have the same length, but one has a cross-section three times that of the other, the resistance of the former is one-third that of the latter.

EXAMPLE. The ratio of the cross-sectional area of one wire to that of another of the same length and material is $\frac{257}{101}$. The resistance of the former is 16.3 ohms. What is the resistance of the latter?

Solution. As the resistances are inversely proportional to the cross-sections, the smaller wire has the greater resistance, and we have the proportion

$$\textit{required resistance} : 16.3 :: 257 : 101$$

or,

$$\frac{\textit{required resistance}}{16.3} = \frac{257}{101}$$

Hence,

$$\textit{required resistance} = 16.3 \times \frac{257}{101}$$

$$= 41.5 \text{ ohms (approx.)}$$

Ans. 41.5 ohms.

EXAMPLE. If the resistance of a wire of a certain length and having a cross-sectional area of .0083 square inch is 1.7 ohms, what would be its resistance if the area of its cross-section were .092 square inch?

Solution. Since increasing the cross-sectional area of a wire decreases its resistance, we have the proportion

$$\textit{required resistance} : 1.7 :: .0083 : .092$$

or,

$$\frac{\textit{required resistance}}{1.7} = \frac{.0083}{.092}$$

Hence,

$$\textit{required resistance} = 1.7 \times \frac{.0083}{.092}$$

$$= .15 \text{ ohm (approx.)}$$

Ans. .15 ohm.

As the area of a circle is proportional to the square of its diameter, it follows that the resistance of round conductors are inversely proportional to the squares of their diameters.

EXAMPLE. The resistance of a certain wire having a diameter of .1 inch is 12.6 ohms. What would be its resistance if the diameter were increased to .32 inch?

Solution. The resistances being inversely proportional to the squares of the diameters, we have

$$\textit{required resistance} : 12.6 :: .1^2 : .32^2$$

or,

$$\frac{\textit{required resistance}}{12.6} = \frac{.1^2}{.32^2}$$

Hence,

$$\textit{required resistance} = 12.6 \times \frac{.1^2}{.32^2}$$

$$= \frac{12.6 \times .01}{.1024}$$

$$= 1.23 \text{ ohms (approx.)}$$

Ans. 1.23 ohms.

Specific Resistance. The specific resistance of a substance is the resistance of a portion of that substance of unit length and unit cross-section at a standard temperature. The units commonly used are the centimeter of the inch, and the temperature that of melting ice. The specific resistance may therefore be said to be the resistance (usually stated in microhms) of a centimeter cube or of an inch cube at the temperature of melting ice. If the specific resistances of two substances are known, then their relative resistance is given by the ratio of the specific resistances.

Conductivity. Conductivity is the reciprocal of specific resistance.

EXAMPLE. A certain copper wire at the temperature of melting ice has a resistance of 29.7 ohms. Its specific resistance—resistance of 1 centimeter cube in microhms—is 1.594, and that of platinum is 9.032. What would be the resistance of a platinum wire of the same size and length of the copper wire, and at the same temperature?

Solution. The resistance would be in direct ratio of the specific resistances, and we have the proportion

$$\textit{required resistance} : 29.7 :: 9.032 : 1.594$$

Hence,

$$\textit{required resistance} = 29.7 \times \frac{9.032}{1.594}$$

$$= 168 \text{ ohms (approx.)}$$

Ans. 168 ohms.

Calculation of Resistance. From the preceding pages it is evident that resistance varies directly as the length, inversely as the cross-sectional area, and depends upon the specific resistance of the material. This may be expressed conveniently by the formula

$$R = s\frac{L}{A}$$

in which R is the resistance, L the length of the conductor, A the area of its cross-section, and s the specific resistance of the material.

EXAMPLE. A telegraph relay is wound with 1,800 feet of wire .010 inch in diameter, and has a resistance of 150 ohms. What will be its resistance if wound with 40 feet of wire .022 inch in diameter?

Solution. If the wires were of equal length, we should have the proportion

$$\textit{required resistance}: 150 :: (.010)^2 : (.022)^2$$

or,

$$\textit{required resistance} = 150 \times \frac{(.010)^2}{(.022)^2} = 30.99 + \text{ohms}$$

For a wire 400 feet long, we have, therefore, by direct proportion,

$$\textit{required resistance} = \frac{400}{1,800} \times 30.99 = 6.88+$$

Ans. 6.88 + ohms.

If a circuit is made up of several different materials joined in series with each other, the resistance of the circuit is equal to the sum of the resistances of its several parts. In calculating the resistance of such a circuit, the resistance of each part should first be calculated, and the sum of these resistances will be the total resistance of the circuit.

In Table I is given the resistance of chemically pure substances at 0° centigrade or 32° Fahrenheit in International ohms. The first column of numbers gives the relative resistances when that of annealed silver is taken as unity. For example, mercury has 62.73 times the resistance of annealed silver. The second and third columns give the resistances of a foot of wire .001 inch in diameter, and of a meter of wire 1 millimeter in diameter, respectively. The fourth and fifth columns give respectively the resistance in microhms of a cubic inch and cubic centimeter, that is, the specific resistances.

TABLE I

Relative Resistance of Chemically Pure Substances at 32° F. International Ohms

Metals	Relative Resistance	Resistance of a wire 1 foot long .001 in. in diameter	Resistance of a wire 1 m. long 1 mm. in diameter	Resistance in Microhms	
				Cubic Inch	Cubic Centimeter
Silver, annealed	1.000	9.023	.01911	.5904	1.500
Copper, annealed	1.063	9.585	.02028	.6274	1.594
Silver, hard drawn	1.086	9.802	.02074	.6415	1.629
Copper, hard drawn	1.086	9.803	.02075	.6415	1.629
Gold, annealed	1.369	12.35	.02613	.8079	2.052
Gold, hard drawn	1.393	12.56	.02661	.8224	2.088
Aluminum, annealed	1.935	17.48	.03700	1.144	2.904
Zinc, pressed	3.741	33.76	.07143	2.209	5.610
Platinum, annealed	6.022	54.34	.1150	3.555	9.032
Iron, annealed	6.460	58.29	.1234	3.814	9.689
Lead, pressed	13.05	117.7	.2491	7.706	19.58
German silver	13.92	125.5	.2659	8.217	20.87
Platinum-silver alloy ($\frac{1}{3}$ platinum, $\frac{2}{3}$ silver)	16.21	146.3	.3097	9.576	24.32
Mercury	62.73	570.7	1.208	37.05	94.06

A very small portion of foreign matter mixed with a metal greatly increases its resistance. An alloy of two or more metals always has a higher specific resistance than that of any of its constituents. For example, the conductivity of silver mixed with 1.2 per cent in volume of gold, will be 59 when that of pure silver is taken as 100. Annealing reduces the resistance of metals.

The following examples are given to illustrate the use of Table I in connection with the formula $R = s\,\frac{L}{A}$ and to show the application of preceding laws.

EXAMPLE. From the specific resistance of annealed aluminum as given in the next to the last column of the table, calculate the resistance given in the second column of figures for that substance.

Solution. The resistance in microhms of a cubic inch of annealed aluminum at 32° F. is 1.144, which is equal to .000001144 ohms. The resistance of a wire 1 foot long and .001 inch in diameter is required. According to the formula $s = .000001144$, $L = 1$ foot $= 12$ inches and

$$A = \frac{\pi d^2}{4} = \frac{3.1416 \times .001^2}{4} = .0000007854 \text{ sq. in.}$$

Substituting these values in the formula

$$R = s\frac{L}{A}$$

we have

$$R = .000001144 \times \frac{12}{.0000007854}$$

$$= 17.48 \text{ ohms} \qquad \text{Ans. } 17.48 \text{ ohms.}$$

EXAMPLE. The resistance in microhms of a cubic centimeter of annealed platinum at 32° F. is 9.032. What is the resistance of a wire of the same substance one meter long and one millimeter in diameter at the same temperature?

Solution. In the formula for resistance we have the quantities s = 9.032 microhms = .000009032 ohms; L = 1 meter = 100 centimeters; and

$$A = \frac{\pi d^2}{4} = \frac{3.1416 \times .1^2}{4} = .007854 \text{ sq. cm.}$$

the diameter being equal to 1 millimeter = .1 cm.

Substituting these values we have

$$R = .000009032 \times \frac{100}{.007854}$$

$$= .115 \text{ ohm} \qquad \text{Ans. } .115 \text{ ohm.}$$

EXAMPLE. From Table I the resistance of 1 foot of pure annealed silver wire .001 inch in diameter at 32° F. is 9.023 ohms. What is the resistance of a mile of wire of the same substance .1 inch in diameter at that temperature?

Solution. As the resistance of wires is directly proportional to their length and inversely proportional to the squares of their diameters, the required resistance is found by multiplying the resistance per foot by 5,280 and the product by the inverse squares of the diameters.

$$\text{Therefore, } R = 9.023 \times 5280 \times \left\{\frac{.001}{.1}\right\}^2$$

$$= 4.76 \text{ ohms (approx.)}$$

Ans. 4.76 ohms.

EXAMPLE. A mile and one-half of an annealed wire of pure iron has a resistance of 46.1 ohms. What would be the resistance of hard-drawn wire of pure copper of the same length and diameter, assuming each to be at the temperature of melting ice?

Solution. The only factor involved by this example is the relative resistance of the two metals. From Table I, annealed iron has 6.460 and hard-drawn copper 1.086 times the resistance of annealed silver. Hence, the resistance of the copper is to that of the iron as 1.086 is to 6.460, and the required resistance is

$$R = 46.1 \times \frac{1.086}{6.460} = 7.75 \text{ ohms (approx.)}$$

Ans. 7.75 ohms.

EXAMPLE. If the resistance of a wire 7,423 feet long is 18.7 ohms, what would be its resistance if its length were reduced to 6,253 feet and its cross-section made one half again as large?

Solution. As resistance is directly proportional to the length, and inversely proportional to the area of the cross-section, the required resistance is

$$R = 18.7 \times \frac{6253}{7423} \times \frac{2}{3} = 10.5 \text{ ohms (approx.)}$$

Ans. 10.5 ohms.

Resistance Affected by Heating. The resistance of metals depends upon the temperature, and the resistance is increased by heating. The heating of some substances, among which is carbon, causes a decrease in their resistance. The resistance of the filament of an incandescent lamp when lighted is only about half as great as when cold. All *metals,* however, have their resistance increased by a rise in temperature. The percentage increase in resistance with rise of temperature varies with the different metals, and varies slightly for the same metal at different temperatures. The increase is practically uniform for most metals throughout a considerable range of temperature. The resistance of copper increases about .4 per cent per degree centigrade, or about .22 per cent degree Fahrenheit. The percentage increase in resistance for alloys is much less than for the simple metals. Standard resistance coils are, therefore, made of alloys, as it is desirable that their resistance should be as nearly constant as possible.

The change in resistance of one ohm per degree rise in temperature for a substance is called the *temperature coefficient* for that substance. Table II gives the temperature coefficients for a few substances.

If the resistance of a conductor at a certain temperature is known, the resistance the conductor will have at a higher temperature may be found by multiplying the temperature coefficient for the substance, by the number of degrees increase and by the resistance at the lower temperature, and adding to this result the resistance at the lower temperature. The product of the temperature coefficient by the number of degrees increase gives the increase in resistance of one ohm through that number of degrees, and multiplying this by the number of ohms gives the increase in resistance for the conductor. The result obtained is practically correct for moderate ranges of temperature.

TABLE II

Temperature Coefficients

Material	Rise in R. of 1 Ohm When Heated	
	1° F.	1° C.
Platinoid	.00012	.00022
Platinum-silver	.00014	.00025
German silver	.00022	.00040
Platinum	.0019	.0035
Silver	.0021	.0038
Copper, aluminum	.0022	.0040
Iron	.0026	.0046

The above method of calculating the resistance of conductors at increased temperature is conveniently expressed by the following formula

$$R_2 = R_1\ (1 + at)$$

where R_2 is the resistance at the higher temperature, R_1 that at the lower temperature, a the temperature coefficient for the substance, and t the number of degrees change.

From the preceding formula it follows that if the resistance at the higher temperature is known, that at the lower temperature will be given by the formula

$$R_1 = \frac{R_2}{1 + at}$$

In calculating resistances at different temperatures, the temperature coefficient based on the Fahrenheit scale should be used if the number of degrees change is given in degrees Fahrenheit, and that based on the centigrade scale if given in degrees centigrade.

EXAMPLE. The resistance of a coil of German silver wire at 12° C. is 1,304 ohms. What would be its resistance at a temperature of 60° C.?

Solution. From the statement of the example $R_1 = 1{,}304$, $t = 60 - 12 = 48$, and from Table II, $a = .0004$. Substituting these values in the formula $R_2 = R_1\ (1 + at)$, we have

$$R_1 = 1304\ (1 + .0004 \times 48)$$
$$= 1304 \times 1.0192$$
$$= 1329 \text{ ohms (approx.)}$$

Ans. 1329 ohms.

TABLE III

American Wire Gauge (B. & S.)

No.	Diameter in		Circular Mils	Ohms per 1000 Ft.	No.	Diameter in		Circular Mils	Ohms per 1000 Ft.
	Mils	Millim.				Mils	Millim.		
0000	460.00	11.684	211600.0	.051	19	35.89	.912	1288.0	8.617
000	409.64	10.405	167805.0	.064	20	31.96	.812	1021.5	10.566
00	364.80	9.266	133079.4	.081	21	28.46	.723	810.1	13.323
0	324.95	8.254	105592.5	.102	22	25.35	.644	642.7	16.799
1	289.30	7.348	83694.2	.129	23	22.57	.573	509.5	21.185
2	257.63	6.544	66373.0	.163	24	20.10	.511	404.0	26.713
3	229.42	5.827	52634.0	.205	25	17.90	.455	320.4	33.684
4	204.31	5.189	41742.0	.259	26	15.94	.405	254.0	42.477
5	181.94	4.621	33102.0	.326	27	14.19	.361	201.5	53.563
6	162.02	4.115	26250.5	.411	28	12.64	.321	159.8	67.542
7	144.28	3.665	20816.0	.519	29	11.26	.286	126.7	85.170
8	128.49	3.264	16509.0	.654	30	10.03	.255	100.5	107.391
9	114.43	2.907	13094.0	.824	31	8.93	.277	79.7	135.402
10	101.89	2.588	10381.0	1.040	32	7.95	.202	63.2	170.765
11	90.74	2.305	8234.0	1.311	33	7.08	.108	50.1	215.312
12	80.81	2.053	6529.9	1.653	34	6.30	.160	39.7	271.583
13	71.96	1.828	5178.4	2.084	35	5.61	.143	31.5	342.443
14	64.08	1.628	4106.8	2.628	36	5.00	.127	25.0	431.712
15	57.07	1.450	3256.7	3.314	37	4.45	.113	19.8	544.287
16	50.82	1.291	2582.9	4.179	38	3.96	.101	15.7	686.511
17	45.26	1.150	2048.2	5.269	39	3.53	.090	12.5	865.046
18	40.30	1.024	1624.1	6.645	40	3.14	.080	9.9	1091.865

EXAMPLE. If the resistance of a copper conductor at 95° F. is 48.2 ohms, what would be the resistance of the same conductor at 40° F.?

Solution. In this case $R_2 = 48.2$, $t = 95 - 40 = 55$, and from Table II, $a = .0022$. Substituting these values in the formula $R_1 = \frac{R_2}{1 + at}$ we have

$$R_1 = \frac{48.2}{1 + .0022 \times 55} = \frac{48.2}{1.121}$$

$$= 43 \text{ ohms (approx.)}$$

Ans. 43 ohms.

Table III gives the resistance of the most common sizes of copper wire according to the American or Brown and Sharpe (B. & S.) gauge. The resistance given is for pure copper wire at a temperature of 75° F. or 24° C. The fourth column gives the equivalent number of wires each one mil or one-thousandth of an inch in diameter. This is called the size of the wire in circular mil and is equal to the square of the diameter in mils. The fifth column gives the ohms per thousand feet and the resistance per mile is found by multiplying these values by 5.28. Ordinary commercial copper has a conductivity of about 95 to 97 per cent of that of pure copper. The resistance of commercial wire is, therefore, about 3 to 5 per cent greater than the values given in Table III. The resistance for any metal other than copper may be found by multiplying the resistance given in Table III by the ratio of the specific resistance of the given metal to the specific resistance of copper.

Table IV gives the size of the English or Birmingham wire gauge. The B. & S. is, however, much more frequently used in this country. The Brown and Sharpe gauge is a little smaller than the Birmingham for corresponding numbers.

TABLE IV

Stubs' or Birmingham Wire Gauge (B. W. G.)

No.	Diameter in		No.	Diameter in		No.	Diameter in	
	Mils	Millim.		Mils	Millim.		Mils	Millim.
0000	454	11.53	8	165	4.19	18	49	1.24
00	380	9.65	10	134	3.40	20	35	0.89
1	300	7.62	12	109	2.77	24	22	0.55
4	238	6.04	14	83	2.11	30	12	0.31
6	203	5.16	16	65	1.65	36	4	0.10

EXAMPLES FOR PRACTICE

1. What is the resistance of an annealed silver wire 90 feet long and .2 inch in diameter at 32° F.? Ans. .02+ ohm.

2. What is the resistance of 300 meters of annealed iron wire 4 millimeters in diameter when at a temperature of 0° C.? Ans. 2.31+ ohms.

3. What is the resistance of 2 miles of No. 27 (B. & S.) pure copper wire at 75° F.? Ans. 565+ ohms.

4. The resistance of a piece of copper wire at 32° F. is 3 ohms. What is its resistance at 49° F.? Ans. 3.11+ ohms.

5. The resistance of a copper wire at 52° F. is 7 ohms. What is its resistance at 32° F.? Ans. 6.70+ ohms.

6. What is the resistance of 496 ft. of No. 10 (B. & S.) pure copper wire at 45° F.? Ans. .483+ ohms.

TABLE V

Primary Cells, Electromotive Force, Resistance, Etc.

Name of Cell	Anode	Kathode	Excitant	Depolarizer	E. M. F. in Volts	Internal Resistance in Ohms
Volta (Wollaston, etc.)	Zinc	Copper	Solution of Sulphuric Acid (H_2SO_4)	None	1 to 0.5	
Smee	Zinc	Platinized Silver	Solution of Sulphuric Acid (H_2SO_4)	None	1 to 0.5	0.5
Law	Zinc	Carbon	Solution of Sulphuric Acid (H_2SO_4)	None	1 to 0.5	
Poggendorff (Grenet)	Zinc	Graphite (Carbon)	Solution of Sulphuric Acid (H_2SO_4)	Potassium Dichromate ($K_2Cr_2O_7$)	2.1	
Poggendorff (Grenet) two fluid	Zinc	Graphite (Carbon)	Saturated Solution of Potassium Dichromate and Sulphuric Acid	None Separate	1.98	.001 to .08
Grove	Zinc	Platinum	Sulphuric Acid dilute (H_2SO_4)	Nitric Acid (HNO_3)	1.96	0.1 to 0.12
Bunsen	Zinc	Graphite (Carbon)	Sulphuric Acid dilute (H_2SO_4)	Nitric Acid	1.8 to 1.98	0.08 to 0.11
				Chromic Acid	1.8	0.1 to 0.12
Leclanché		Graphite (Carbon)	Ammonium Chloride (NH_4Cl)	Manganese Dioxide (MnO_2)	1.4 to 1.6	1.13 to 1.15
Lalande Lalande–Chaperon	Zinc	Graphite (Carbon)	Caustic Potash or Potassium Hydrate (KOH)	Cupric Oxide	0.8 to 0.9	1.3
Upward	Zinc	Graphite (Carbon)	Zinc Chloride ($ZnCl_2$)	Chlorine (Cl)	2.0	
Fitch	Zinc	Graphite (Carbon)	Ammonium Chloride (NH_4Cl)	Sodium & Potassium Chlorates ($NaClO_3$ + $KClO_3$)	1.1	
Papst	Iron	Graphite (Carbon)	Ferric Chloride (Fe_2Cl_6)	[(Fe_2Cl)	0.4	
Obach (dry)	Zinc	Graphite (Carbon)	Ammonium Chloride (NH_4Cl) in Calcium Sulphate ($CaSO_4$)	Manganese Dioxide (MnO_2)	1.46	
Daniell (Meidinger Minotto, etc.)	Zinc	Copper	Zinc Sulphate ($ZnSO_4$)	Copper Sulphate ($CuSO_4$)	1.079	2 to 5
De la Rue	Zinc	Silver	Ammonium Chloride	Silver Chloride (AgCl)	1.03 to 1.42	0.4 to 0.6
Marie Davy	Zinc	Graphite (Carbon)	Sulphuric Acid dilute (H_2SO_4)	Paste of Sulphate of Mercury (Hg_2SO_4)	1 52	0.75 to 1
Clark (Standard)	Zinc	Mercury	Zinc Sulphate ($ZnSo_4$)	Mercurous Sulphate (Hg_2SO_4)	1.434*	0.3 to 0.5
Weston	Cadmium	Mercury	Cadmium Sulphate ($CdSO_4$)	Mercurous Sulhate (Hg_2SO_4)	1.025	

*At 15 degrees centigrade or 59 degrees Fahrenheit.

TABLE V (Continued)

Name of Cell	Anode	Kathode	Excitant	Depolarizer	E. M. F. in Volts	Internal Resistance in Ohms
Von Helmholtz	Zinc	Mercury	Zinc Chloride ($ZnCl_2$)	Mercurous Chloride (Hg_2Cl_2)	1.0	
Chromic Acid single fluid	Zinc	Graphite (Carbon)	Sulphuric and Chromic Acids, dilute mixed	None Separate	2.2	.016 to .08
Fuller	Zinc	Graphite (Carbon)	Sulphuric Acid (H_2SO_4)	Potassium Dichromate ($K_2Cr_2O_7$)	2.0	0.5 to 0.7
Gaiffe	Zinc	Silver	Zinc Chloride ($ZnCl_2$)	Silver Chloride (AgCl)	1.02	0.5 to 0.6
Maiche	Zinc scraps in bath of Mercury	Platinized Carbon	Common Salt Solution *i. e.* Sodium Chloride (NaCl)	None Separate	1.25	1 to 2
Niaudet	Zinc	Graphite (Carbon)	Common Salt Solution *i. e.* Sodium Chloride (NaCl)	Chloride of Calcium (Lime) ($CaCl_2$)	1.0 to 1.6	5 to 6
Schanschieff	Zinc	Graphite (Carbon)	Mercurial Solution	None Separate	1.56	0.05 to 0.75
Skrivanoff	Zinc	Silver	Caustic Potash or Potassium Hydrate (KOH)	Chloride of Silver (AgCl)	1.5	1.5

Resistances in last column measured in cells standing 6″ × 4″

Table V discloses among other data the resistance of various primary cells. The resistance of a circuit of which a battery forms a part is made up of the external resistance, or the resistance of outside wires and connections, and the internal resistance, or the resistance of the battery itself. The terms *anode* and *kathode* appearing in the second and third columns, are commonly used with reference to electrolysis but may also be applied to primary cells. The current passes from the anode to the kathode through the cell and, therefore, with reference to the cell itself, the anode may be considered the positive element and the kathode the negative element. In regard to the outside circuit, however, the current passes, of course, from the kathode to the anode, and hence with reference to the outside circuit the kathode is positive and the anode negative; ordinarily, the external circuit is considered. As the anode of almost all primary cells is zinc it may readily be remembered that the current passes from the other element *to* the zinc through the *external* circuit.

APPLICATIONS OF OHM'S LAW

Ohm's law is one of the most important and most used laws of electricity.

Current is directly proportional to the electromotive force and inversely proportional to the resistance.

That is, if the electromotive force applied to a circuit is increased, the current will be increased in the same proportion, and if the resistance of a circuit is increased, then the current will be decreased proportionally. Likewise a decrease in the electromotive force causes a proportional decrease in current, and a decrease in resistance causes a proportional increase in current. The current depends only upon the electromotive force and resistance and in the manner expressed by the above simple law. The law may be expressed algebraically as follows

$$\textit{current} \propto \frac{\textit{electromotive force}}{\textit{resistance}}$$

The units of these quantities, the ampere, volt, and ohm, have been so chosen that an electromotive force of 1 volt applied to a resistance of 1 ohm, causes 1 ampere of current to flow. Ohm's law may, therefore, be expressed by the equation

$$C = \frac{E}{R}$$

where C is the current in amperes, E the electromotive force in volts, and R the resistance in ohms.

It is, therefore, evident that if the electromotive force and resistance are known the current may be found, or if any two of the three quantities are known the third may be found. If the current and resistance are known the electromotive force may be found from the formula

$$E = RC$$

and if the current and electromotive force are known, the resistance may be found from the formula

$$R = \frac{E}{C}$$

Simple Applications. The following examples are given to illustrate the simplest applications of Ohm's law:

EXAMPLE. If the e. m. f. applied to a circuit is 4 volts and its resistance is 2 ohms, what current will flow?

Solution. By the formula for current

$$C = \frac{E}{R} = \frac{4}{2} = 2 \text{ amperes}$$

Ans. 2 amperes.

EXAMPLE. What voltage is necessary to cause a current of 23 amperes to flow through a resistance of 820 ohms?

Solution. By the formula for e. m. f.,

$$E = RC = 820 \times 23 = 18{,}860 \text{ volts.}$$

Ans. 18,360 volts.

EXAMPLE. The e. m. f. applied to a circuit is 110 volts, and it is desired to obtain a current of .6 ampere. What should be the resistance of the circuit?

Solution. By the formula for resistance

$$R = \frac{E}{C} = \frac{110}{.6} = 183.+ \text{ ohms.}$$

Ans. 183+ ohms.

Series Circuits. A circuit made up of several parts all joined in series with each other, is called a series circuit and the resistance of the entire circuit is, of course, the sum of the separate resistances. In calculating the current in such a circuit the total resistance must first be obtained, and the current may then be found by dividing the applied or total e. m. f. by the total resistance. This is expressed by the formula

$$C = \frac{E}{R_1 + R_2 + R_3 + \text{etc.}}$$

EXAMPLE. Three resistance coils are connected in series with each other and have a resistance of 8, 4 and 17 ohms respectively. What current will flow if the e. m. f. of the circuit is 54 volts?

Solution. By the preceding formula

$$C = \frac{E}{R_1 + R_2 + R_3} = \frac{54}{8 + 4 + 17} = \frac{54}{29} = 1.8+ \text{ amperes}$$

Ans. 1.8+ amperes.

EXAMPLE. Six arc lamps, each having a resistance of 5 ohms, are connected in series with each other and the resistance of the connecting wires and other apparatus is 3.7 ohms. What must be the pressure of the circuit to give a desired current of 9.6 amperes?

Solution. The total resistance of the circuit is $R = (6 \times 5) + 3.7 = 33.7$ ohms and the current is to be $C = 9.6$ amperes. Hence, by the formula for e. m. f.,

$$E = RC = 33.7 \times 9.6 = 323.+ \text{ volts.}$$

Ans. 323+ volts.

EXAMPLE. The current passing in a certain circuit was 12 amperes and the e. m. f. was 743 volts. The circuit was made up of 4 sections all connected in series, and the resistance of three sections was 16, 9, and 26 ohms, respectively. What was the resistance of the fourth section?

Solution. Let x = the resistance of the fourth section, then $R = 16 + 9 + 26 + x = 51 + x, C = 12$, and $E = 743$. By the formula for resistance

$$R = \frac{E}{C} \text{ or, } 51 + x = \frac{743}{12} = 61.9 \text{ ohms (approx.)}$$

If $51 + x = 61.9$ we have, by transposing 51 to the other side of the equation

$$x = 61.9 - 51 = 10.9 \text{ ohms}$$

Ans. 10.9 ohms.

EXAMPLE. A current of 54 amperes flowed through a circuit when the e. m. f. was 220 volts. What resistance should be added in series with the circuit to reduce the current to 19 amperes?

Solution. The resistance in the first case was

$$R = \frac{220}{54} = 4.07 \text{ ohms (approx.)}$$

The resistance in the second must be

$$R = \frac{220}{19} = 11.58 \text{ ohms (approx.)}$$

The required resistance to insert in the circuit is the difference of these two resistances, or $11.58 - 4.07 = 7.51$ ohms.

Ans. 7.51 ohms.

Fall of Potential in a Circuit. Fig. 28 illustrates a series circuit in which the resistances A, B, C, D, and E are connected in series

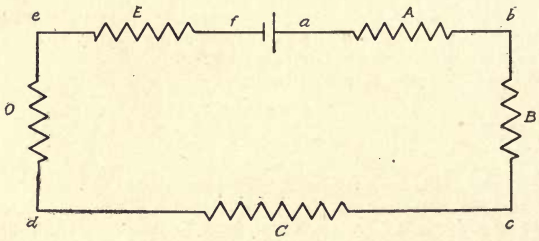


Fig. 28. Battery Circuit Through Resistances in Series

with each other and with the source of electricity. If the e. m. f. is known, the current may be found by dividing the e. m. f. by the sum of all the resistances. Ohm's law may, however, be applied to any

SHE LEARNS THE LESSON OF PATIENCE AND INDUSTRY
Scene from Photoplay, "Her Humble Ministry"
Courtesy of *Lubin Manufacturing Company, Philadelphia*

SCENE FROM PHOTOPLAY, "THE CHILD AND THE TRAMP"
Courtesy of *Thomas A. Edison, Inc., Orange, N. J*

part of a circuit separately, as well as to the complete circuit. Suppose the resistances of A, B, C, D, and E are 4, 3, 6, 3, and 4 ohms, respectively, and assume that the source has no resistance. Suppose the current flowing to be 12 amperes. The e. m. f. necessary to force a current of 12 amperes through the resistance A of 4 ohms is, by applying Ohm's law, equal to $E = R\,C = 4 \times 12 = 48$ volts. Hence, between the points a and b outside of the resistance A, there must be a difference of potential of 48 volts to force the current through this resistance. Also to force the same current through B, the voltage necessary is $3 \times 12 = 36$. Similarly, for each part C, D, and E, there are required 72, 36, and 48 volts, respectively.

As 48 volts are necessary for part A and 36 volts for part B, it is evident that to force the current through both parts a difference of potential of $48 + 36 = 84$ volts is required; that is, the voltage between the points a and c must be 84 volts. For the three parts A, B, and C, $48 + 36 + 72 = 156$ volts are necessary, and for the entire circuit, 240 volts must be applied to give the current of 12 amperes. From the above it is evident that there is a gradual fall of potential throughout the circuit, and if the voltage between any two points of the circuit be measured, the e. m. f. obtained would depend upon the resistance included between these two points. For example, the voltage between points b and d would be found to be $72 + 36 = 108$ volts, or between d and e, 36 volts, etc. From the preceding it is apparent that the fall of potential in a part of a circuit is equal to the current multiplied by the resistance of that part.

This gradual fall of potential, or *drop* as it is commonly called, throughout a circuit, enters into the calculations for the size of conductors or mains supplying current to distant points. The resistances of the conductors cause a certain drop in transmitting the current, depending upon their size and length, and it is, therefore, necessary that the voltage of machines at the supply station shall be great enough to give the voltage necessary at the receiving stations as well as the additional voltage lost in the conducting mains.

For example, in Fig. 28 the voltage necessary between the points e and b is 144 volts, but to give this voltage the source must supply in addition the voltage lost in parts A and E, which equals 96 volts.

Example. The voltage required by 17 arc lamps connected in series is 782 volts and the current is 6.6 amperes. The resistance of the connecting wires is 7 ohms. What must be the e. m. f. applied to the circuit?

Solution. The drop in the connecting wires is $E = R\,C = 7 \times 6.6 =$ 46.2 volts. The e.m.f. necessary is, therefore, $782 + 46.2 = 828.2$ volts.

Ans. 828.2+ volts.

Example. The source of e. m. f. supplies 114 volts to a circuit made up of incandescent lamps and conducting wires. The lamps require a voltage of 110 at their terminals, and take a current of 12 amperes. What should be the resistance of the conducting wires in order that the lamps will receive the necessary voltage?

Solution. The allowable drop in the conducting wires is $114 - 110 = 4$ volts. The current to pass through the wires is 12 amperes. Hence, the resistance must be

$$R = \frac{E}{C} = \frac{4}{12} = .33+ \text{ ohms}$$

Ans. .33 ohms.

Divided Circuits. When a circuit divides into two or more parts, it is called a *divided* circuit and each part will transmit a portion of the current.

Such a circuit is illustrated in Fig. 29, the two branches being represented by *b* and *c*. The current passes from the positive pole of the battery through *a* and then divides; part of the current passing

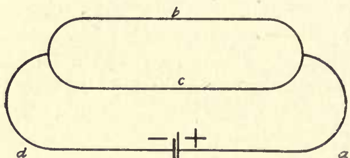


Fig. 29. Divided Circuits

through *b* and part through *c*. The current then unites and passes through *d* to the negative pole of the battery. The part *c* may be considered as the main part of the circuit and *b* as a by-pass about it. A branch which serves as a by-pass to another circuit is called a *shunt* circuit, and the two branches are said to be connected in *parallel.*

In considering the passage of a current through a circuit of this sort, it may be necessary to determine how much current will pass through one branch and how much through the other. Evidently this will depend upon the relative resistance of the two branches, and more current will pass through the branch offering the lesser resistance than through the branch having the higher resistance. If the two parts have equal resistances, then one-half of the total current will pass through each branch. If one branch has twice the resistance of the other, then only one-half as much of the total current will pass through that branch as through the other; that is, one-third of the total current will pass through the first branch and the remaining two-thirds will pass through the second.

The relative strength of current in the two branches will be inversely proportional to their resistances, or directly proportional to their conductances.

Suppose the resistance of one branch of a divided circuit is r_1, Fig. 30, and that of the other is r_2. Then by the preceding law

$$\text{current in } r_1 : \text{current in } r_2 :: r_2 : r_1$$

Also,

$$\text{current in } r_1 : \text{total current} :: r_2 : r_1 + r_2$$

and

$$\text{current in } r_2 : \text{total current} :: r_1 : r_1 + r_2$$

Let C represent the total current, i_1 the current through the resistance r_1 and i_2 the current through the resistance r_2. Then the

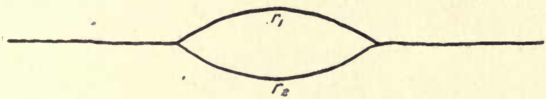


Fig. 30. Joint Resistance of a Divided Circuit

two preceding proportions are expressed by the following formulas

$$i_1 = \frac{Cr_2}{r_1 + r_2} \text{ and } i_2 = \frac{Cr_1}{r_1 + r_2}$$

EXAMPLE. The total current passing in a circuit is 24 amperes. The circuit divides into two branches having resistances of 5 and 7 ohms, respectively. What is the current in each branch?

Solution. In this case $C = 24$, $r_1 = 5$, and $r_2 = 7$. Substituting these values in the above formulas, we have

$$i_1 = \frac{Ir_2}{r_1 + r_2} = \frac{24 \times 7}{5 + 7} = 14 \text{ amperes}$$

and

$$i_2 = \frac{Ir_1}{r_1 + r_2} = \frac{24 \times 5}{7 + 7} = 10 \text{ amperes}$$

Ans. { In 5 ohm branch, 14 amperes.
In 7 ohm branch, 10 amperes.

Joint Resistance of Divided Circuits. As a divided circuit offers two paths to the current, it follows that the joint resistance of the two branches will be less than the resistance of either branch alone. The ability of a circuit to conduct electricity is represented by its conductance, which is the reciprocal of resistance; and the conductance of a divided circuit is equal to the sum of the conductances of its parts.

For example, in Fig. 30, the conductance of the upper branch equals $\frac{1}{r_1}$ and that of the lower branch equals $\frac{1}{r_2}$. If R represents the joint resistance of the two parts then the joint conductance equals

$$\frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2} = \frac{r_1 + r_2}{r_1 r_2}$$

Having thus obtained the joint conductance, the joint resistance is found by taking the reciprocal of the conductance, that is,

$$R = \frac{r_1 r_2}{r_1 + r_2}$$

This formula may be stated as follows:

The joint resistance of a divided circuit is equal to the product of the two separate resistances divided by their sum.

For example, suppose the resistance of each branch to be 2 ohms. The conductance of the circuit will be,

$$\frac{1}{R} = \frac{1}{2} + \frac{1}{2} = 1, \text{ and hence } R = 1 \text{ ohm}$$

Also by the preceding formula

$$R = \frac{2 \times 2}{2 + 2} = 1 \text{ ohm}$$

The resistance of a divided circuit in which each branch has a resistance of 2 ohms is, therefore, 1 ohm.

EXAMPLE. The resistances of two separate conductors are 3 and 7 ohms, respectively. What would be their joint resistance if connected in parallel?

Solution. In this case $r_1 = 3$ and $r_2 = 7$, hence, by the formula

$$R = \frac{3 \times 7}{3 + 7} = 2.1 \text{ ohms.}$$

Ans. 2.1 ohms.

Suppose, as illustrated in Fig. 31, the conductors having resistances equal to r_1, r_2, and r_3, respectively, are connected in parallel. The joint total conductance will then be equal to

$$\frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} = \frac{r_2 r_3 + r_1 r_3 + r_1 r_2}{r_1 r_2 r_3}$$

and as the joint resistance is the reciprocal of the joint conductance, the joint resistance R of the three branches is expressed by the formula

$$R = \frac{r_1 r_2 r_3}{r_2 r_3 + r_1 r_3 + r_1 r_2}$$

Example. What is the joint resistance when connected in parallel, of three wires whose respective resistances are 41, 52, and 29 ohms, respectively?

Solution. In this case $r_1 = 41$, $r_2 = 52$, and $r_3 = 29$.
Hence, by the preceding formula,

$$R = \frac{41 \times 52 \times 29}{52 \times 29 + 41 \times 29 + 41 \times 52} = 12.8+ \text{ ohms.}$$

Ans. 12.8+ ohms.

In general, for any number of conductors connected in parallel, the joint resistance is found by taking the reciprocal of the sum of the reciprocals of the separate resistances.

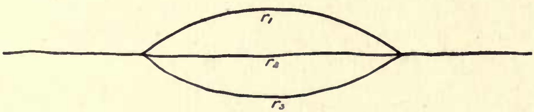


Fig. 31. Triply Divided Circuit

Example. A circuit is made up of five wires connected in parallel, and their separate resistances are respectively 12, 21, 28, 8, and 42 ohms. What is the joint resistance?

Solution. The sum of the conductances is

$$\frac{1}{12} + \frac{1}{21} + \frac{1}{28} + \frac{1}{8} + \frac{1}{42} = \frac{53}{168}$$

Hence the joint resistance equals

$$R = \frac{168}{53} = 3.1+ \text{ ohms}$$

Ans. 3.1+ ohms.

If the resistance of each branch is known and also the potential difference between the points of union, then the current in each branch may be found by applying Ohm's law to each branch separately. For example, if this potential difference were 96 volts, and the separate resistances of the 4 branches were 8, 24, 3, and 48 ohms, respectively, then the current in the respective branches would be 12, 4, 32, and 2 amperes, respectively.

If the current in each branch is known, and also the potential difference between the points of union, then the resistance of each branch may likewise be found from Ohm's law.

The following examples are given to illustrate the application of the preceding principles.

EXAMPLES FOR PRACTICE

1. Two conductors having resistances of 71 and 19 ohms, respectively, are connected in parallel, and the total current passing in the circuit is 37 amperes. What current passes in the conductor whose resistance is 71 ohms? Ans. 7.8+ amperes.

2. What is the joint resistance of two wires connected in parallel if their separate resistances are 2 and 8 ohms, respectively? Ans. 1.6 ohms.

3. What is the joint resistance of three wires when connected in parallel, whose separate resistances are 5, 7, and 9 ohms, respectively? Ans. 2.2+ ohms.

4. Three wires, the respective resistances of which are 8, 10, and 20 ohms, are joined in parallel. What is their joint resistance? Ans. 3.6+ ohms.

5. Four wires are joined in parallel, and their separate resistances are 2, 4, 6, and 9 ohms, respectively. What is the joint resistance of the conductor thus formed? Ans. .97+ ohms.

WIRING METHODS

PLANNING AN INSTALLATION

The first step in planning a wiring installation, is to gather all tne data which will affect either directly or indirectly the system of wiring and the manner in which the conductors are to be installed. The data will include: Kind of building; construction of building; space available for conductors; source and system of electric-current supply; and all details which will determine the method of wiring to be employed. These last items materially affect the cost of the work, and are usually determined by the character of the building and by commercial considerations.

Method of Wiring. In a modern fireproof building, the only system of wiring to be recommended is that in which the conductors are installed in rigid conduits; although, even in such cases, it may be desirable, and economy may be effected thereby, to install the larger feeder and main conductors exposed on insulators using weatherproof slow-burning wire. This latter method should be used, however, only where there is a convenient runway for the conductors, so that they will not be crowded and will not cross pipes, ducts, etc., and also will not have too many bends. Also, the local inspection authorities should be consulted before using this method.

For mills, factories, etc., wires exposed on cleats or insulators are usually to be recommended, although rigid conduit, flexible conduit, or armored cable may be desirable.

In finished buildings, and for extensions of existing outlets, where the wiring could not readily or conveniently be concealed, moulding is generally used, particularly where cleat wiring or other exposed methods of wiring would be objectionable. However, as has already been said, moulding should not be employed where there is any liability to dampness.

In finished buildings, particularly where they are of frame construction, flexible steel conduits or armored cable are to be recommended.

While in new buildings of frame construction, knob and tube wiring is frequently employed, this method should be used only where the question of first cost is of prime importance. While armored cable will cost approximately 50 to 100 per cent more than knob and tube wiring, the former method is so much more permanent and is so much safer that it is strongly recommended.

Systems of Wiring. The system of wiring—that is, whether the two-wire or the three-wire system shall be used—is usually determined by the source of supply. If the source of supply is an isolated plant, with simple two-wire generators, and with little possibility of current being taken from the outside at some future time, the wiring in the building should be laid out on the two-wire system. If, on the other hand, the isolated plant is three-wire (having three-wire generators, or two-wire generators with balancer sets), or if the current is taken from an outside source, the wiring in the building should be laid out on a three-wire system.

It very seldom happens that current supply from a central station is arranged with other than the three-wire system inside of buildings, because, if the outside supply is alternating current, the transformers are usually adapted for a three-wire system. For small buildings, on the other hand, where there are only a few lights and where there would be only one feeder, the two-wire system is used. As a rule, however, when the current is taken from an outside source, it is best to consult the engineer of the central station supplying the current, and to conform with his wishes. As a matter of fact, this should be done in any event, in order to ascertain the proper voltage for the lamps and for the motors, and also to ascertain whether the central station will supply transformers, meters, and lamps, for, if these are not thus supplied, they should be included in the contract for the wiring.

Location of Outlets. A set of plans, including elevation and details, if any, and showing decorative treatment of the various rooms, should be obtained from the architect. A careful study should then be made by the architect, the owner, and the engineer, or some other person qualified to make recommendations as to illumination. The location of the outlets will depend: *First,* upon the decorative treatment of the room, which determines the æsthetic and architectural effects; *second,* upon the type and general form of fixtures to be used, which should be previously decided on; *third,* upon the tastes of the owners or occupants in regard to illumination in general, as it is found that tastes vary widely in regard to amount and kind of illumination.

The location of the outlets, and the number of lights required at each, having been determined, the outlets should be marked on the plans.

The architect should then be consulted as to the location of the centers of distribution, the available points for the risers or feeders, and the available space for the branch circuit conductors.

In regard to the *rising points for the feeders and mains,* the following precautions should be used in selecting chases:

The space should be amply large to accommodate all the feeders and mains likely to rise at that given point. This seems trite and unnecessary but it is the most usual trouble with chases for risers. Formerly architects and builders paid little attention to the requirements for chases for electrical work; but in these later days of 2-inch and 2½-inch conduit, they realize that these pipes are not so invisible and mysterious as the force they serve to distribute, particularly when twenty or more such conduits must be stowed away in a building where no special provision has been made for them.

If possible, the space should be devoted solely to electric wiring. Steam pipes are objectionable on account of their temperature; and these and all other pipes are objectionable in the same space occupied by the electrical conduits, for if the space proves too small, the electric conduits are the first to be crowded out.

The chase, if possible, should be continuous from the cellar to the roof, or as far as needed. This is necessary in order to avoid unnecessary bends or elbows, which are objectionable for many reasons.

In similar manner, the location of *cut-out cabinets or distributing centers* should fulfill the following requirements:

They should be accessible at all times.

They should be placed sufficiently close together to prevent the circuits from being too long.

They should not be placed in too prominent a position, as that is objectionable from the architect's point of view.

They should be placed as near as possible to the rising chases, in order to shorten the feeders and mains supplying them.

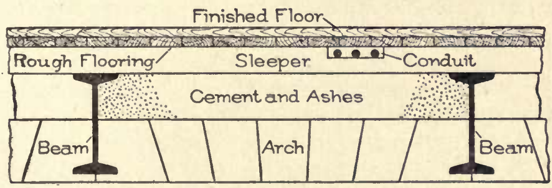


Fig. 32. Running Conductors Concealed Under Floor in Fireproof Building

Having determined the system and method of wiring, the location of outlets and distributing centers, the next step is to lay out the *branch circuits* supplying the various outlets.

Before starting to lay out the branch circuits, a drawing showing the floor construction, and showing the space between the top of the beams and girders and the flooring, should be obtained from the architect. In fireproof buildings of iron or steel construction, it is almost the invariable practice, where the work is to be concealed, to run the conduits over the beams, under the rough flooring, carrying them between the sleepers when running parallel to the sleepers, and notching the latter when the conduits run across them, Fig. 32. In wooden frame buildings, the conduits run parallel to the beams and to the furring, Fig. 33; they are also sometimes run below the beams. In the latter case the beams have to be notched, and this is allowable only in certain places, usually near the points where the beams are supported. The architect's drawing is, therefore, necessary in order that the location and course of the conduits may be indicated on the plans.

The first consideration in laying out the branch circuit is the *number of outlets* and *number of lights* to be wired on any one branch circuit. The *Rules of the National Electric Code* require that "no set of incandescent lamps requiring more than 660 watts, whether grouped on one fixture or on several fixtures or pendents, will be dependent on one cut-out." While it would be possible to have branch circuits supplying more than 660 watts, by placing various cut-outs at different points along the route of the branch circuit, so as to subdivide it into small sections to comply with the rule, this method is not recommended, except in certain cases, for exposed wiring in factories or mills. As a rule, the proper method is to have the cut-outs located at the center

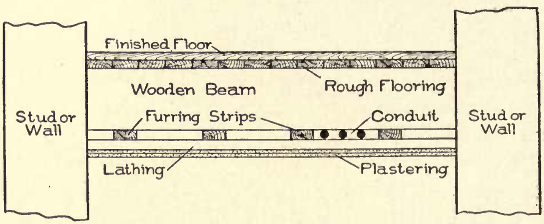


Fig. 33. Running Conductors Concealed Under Floor in Wooden Frame Building

of distribution, and to limit each branch circuit to 660 watts, which corresponds to twelve or thirteen 50-watt lamps, twelve being the usual limit. Attention is called to the fact that the inspectors usually allow 50 watts for each socket connected to a branch circuit; and although 8-candle-power lamps may be placed at some of the outlets, the inspectors hold that the standard lamp is approximately 50 watts, and for that reason there is always the likelihood of a lamp of that capacity being used, and their inspection is based on that assumption. Therefore, to comply with the requirements, an allowance of not more than twelve lamps per branch circuit should be made.

In ordinary practice, however, it is best to reduce this number still further, so as to make allowance for future extensions or to increase the number of lamps that may be placed at any outlet. For this reason, it is wise to keep the number of the outlets on a circuit at the lowest point consistent with economical wiring. It has been proven by actual practice, that the best results are obtained by limiting the number to five or six outlets on a branch circuit. Of course, where all the outlets have a single light each, it is frequently necessary, for reasons of economy, to increase this number to eight, ten, and, in some cases, twelve outlets.

Now, as to the course of the circuit work, little need be said, as it is largely influenced by the relative position of the outlets, cut-outs, switches, etc. Between the cut-out box and the first outlet, and between the outlets, it will have to be decided, however, whether the circuits shall run at right angles to the walls of the building or room, or whether they shall run direct from one point to another, irrespective of the angle they make to the sleepers or beams. Of course, in the latter case, the advantages are that the cost is somewhat less and the number of elbows and bends is reduced. If the tubes are bent, however, instead of using elbows, the difference in cost is usually very slight, and probably does not compensate for the disadvantages that would result from running the tubes diagonally. As to the number of bends, if branch circuit work is properly laid out and installed, and a proper size of tube used, it rarely happens that there is any difference in "pulling" the branch circuit wires. It may happen, in the event of a very long run or one having a large number of bends, that it might be advisable to adopt a short and more direct route.

Up to this time, the location of the distribution centers has been made solely with reference to architectural considerations; but they must now be considered in conjunction with the branch circuit work.

It frequently happens that, after running the branch circuits on the plans, we find, in certain cases, that the position of centers of distribution may be changed to advantage, or sometimes certain groups may be dispensed with entirely and the circuits run to other points. We now see the wisdom of ascertaining from the architect where cut-out groups may be located, rather than selecting particular points for their location.

As a rule, wherever possible, it is wise to limit the length of each branch circuit to 100 feet; and the number and location of the distributing centers should be determined accordingly.

It may be found that it is sometimes necessary and even desirable to increase the limit of length. One instance of this may be found in hall or corridor lights in large buildings. It is generally desirable, in such cases, to control the hall lights from one point; and, as the number of lights at each outlet is generally small, it would not be economical to run mains for sub-centers of distribution. Hence, in instances of this character, the length of runs will frequently exceed the limit named. In the great majority of cases, however, the best results are obtained by limiting the runs to 90 or 100 feet.

There are several good reasons for placing such a limit on the length of a branch circuit. To begin with, assuming that we are going to place a limit on the loss in voltage (drop) from the switchboard to the lamp, it may easily be proven that up to a certain reasonable limit it is more economical to have a larger number of distributing centers and shorter branch circuits, than to have fewer centers and longer circuits. It is usual, in the better class of work, to limit the loss in voltage in any branch circuit to approximately one volt. Assuming this limit (one volt loss), it can readily be calculated that the number of lights at one outlet which may be connected on a branch circuit 100 feet long (using No. 14 B. & S. wire), is *four;* or in the case of outlets having a single light each, *five* outlets may be connected on the circuit, the first being 60 feet from the cut-out, the others being 10 feet apart.

These examples are selected simply to show that, if the branch circuits are much longer than 100 feet, the loss must be increased to more than one volt, or else the number of lights that may be connected to one circuit must be reduced to a very small quantity, provided, of course, the size of the wire remains the same.

Either of these alternatives is objectionable—the first, on the score of regulation; and the second, from an economical standpoint. If, for instance, the loss in a branch circuit with all the lights turned on is four volts (assuming an extreme case), the voltage at which a lamp on that circuit burns will vary from four volts, depending on the number of lights burning at a time. This, of course, will cause the lamp to burn below candle-power when all the lamps are turned on, or else to diminish its life by burning above the proper voltage when it is the only lamp burning on the circuit. Then, too, if the drop in the branch circuits is increased, the sizes of the feeders and the mains must be correspondingly increased (if the total loss remains the same), thereby increasing their cost.

If the number of lights on the circuit is decreased, we do not use to good advantage the available carrying capacity of the wire.

Of course, one solution of the problem would be to increase the size of the wire for the branch circuits, thus reducing the drop. This, however, would not be desirable, except in certain cases where there were a few long circuits, such as for corridor lights or other special control circuits. In such instances as these, it would be better to increase the sizes of the branch circuit to No. 12 or even No. 10 B. &. S. gauge conductors, than to increase the numbers of centers of distribution for the sake of a few circuits only, in order to reduce the number of lamps (or loss) within the limit.

The method of calculating the loss in conductors has been given elsewhere; but it must be borne in mind, in calculating the loss of a branch circuit supplying more than one outlet, that separate calculations must be made for each portion of the circuit. That is, a calculation must be made for the loss to the first outlet, the length in this case being the distance from the center of distribution to the first outlet, and the load being the total number of lamps supplied by the circuit. The next step would be to obtain the loss between the first and second outlet, the length being the distance between the two outlets, and the load, in this case, being the total number of lamps supplied by the circuit, *minus* the number supplied by the first outlet; and so on. The loss for the total circuit would be the sum of these losses for the various portions of the circuits.

Feeders and Mains. If the building is more than one story, an elevation should be made showing the height and number of stories. On this elevation, the various distributing centers should be shown diagrammatically; and the current in amperes supplied through each center of distribution, should be indicated at each center. The next step is to lay out a tentative system of feeders and mains, and to ascertain the load in amperes supplied by each feeder and main. The estimated length of each feeder and main should then be determined, and calculation made for the loss from the switchboard to each center of distribution. It may be found that in some cases it will be necessary to change the arrangement of feeders or mains, or even the centers of distribution, in order to keep the total loss from the switchboard to the lamps within the limits previously determined. As a matter of fact, in important work, it is always best to lay out the entire work tentatively in a more or less crude fashion, according to the "cut-and-dried" method, in order to obtain the best results, because the entire layout may be modified after the first preliminary layout has been made. Of course, as one becomes more experienced and skilled in these matters, the final layout is often almost identical with the first preliminary arrangement.

WIRING AN OFFICE BUILDING

The building selected as a typical sample of a wiring installation is that of an office building located in Washington, D. C. The figures shown are reproductions of the plans actually used in installing the work.

The building consists of a basement and ten stories. It is of fireproof construction, having steel beams with terra-cotta flat arches. The main walls are of brick and the partition walls of terra-cotta blocks, finished with plaster. There is a space of approximately five inches between the top of the iron beams and the top of the finished floor, of which space about 3 inches was available for running the electric conduits. The flooring is of wood in the offices, but of concrete, mosaic, or tile in the basement, halls, toilet-rooms, etc.

The electric current supply is derived from the mains of the local illuminating company, the mains being brought into the front of the building and extending to a switchboard located near the center of the basement.

As the building is a very substantial fireproof structure, the only method of wiring considered was that in which the circuits would be installed in iron conduits.

Electric Current Supply. The electric current supply is direct current, two-wire for power, and three-wire for lighting, having a potential of 236 volts between the outside conductors, and 118 volts between the neutral and either outside conductor.

Switchboard. On the switchboard in the basement are mounted wattmeters, provided by the local electric company, and the various switches required for the control and operation of the lighting and power feeders. There is a total of ten triple-pole switches for lighting, and eighteen for power. An indicating voltmeter and ampere meter are also placed in the switchboard. A voltmeter is provided with a double-throw switch, and so arranged as to measure the potential across the two outside conductors, or between the neutral conductor and either of the outside conductors. The ampere meter is arranged with two shunts, one being placed in each outside leg; the shunts are connected with a double-pole, double-throw switch, so that the ampere meter can be connected to either shunt and thus measure the current supplied on each side of the system.

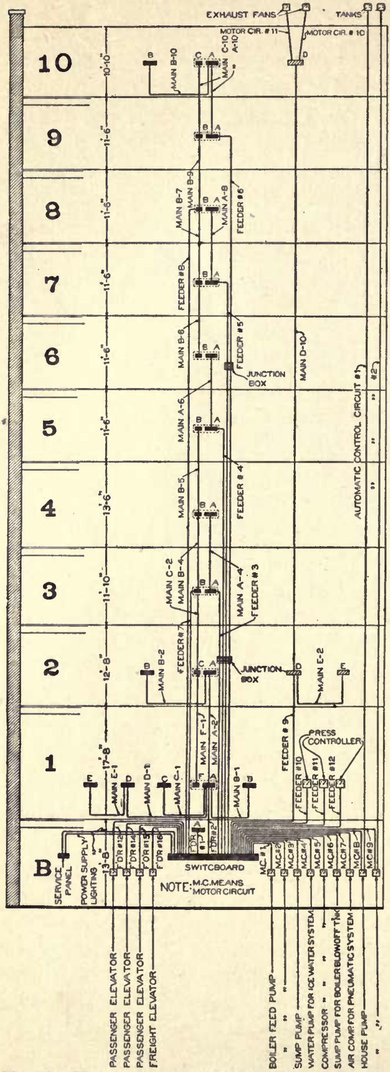
Character of Load. The building is occupied partly as a newspaper office, and there are several large presses in addition to the usual linotype machines, trimmers, shavers, cutters, saws, etc. There are also electrically-driven exhaust fans, house pumps, air-compressors, etc. The upper portion of the building is almost entirely devoted to offices rented to outside parties. The total number of motors supplied was 55; and the total number of outlets, 1,100, supplying 2,400 incandescent lamps and 4 arc lamps.

Feeders and Mains. The arrangement of the various feeders and mains, the cut-out centers, mains, etc., which they supply, are shown diagrammatically in Fig. 34, which also gives in schedule the sizes of feeders, mains, and motor circuits, and the data relating to the cut-out panels.

Although the current supply was to be taken from an outside source, yet, inasmuch as there was a probability of a plant being installed in the building itself at some future time, the three-wire system of feeders and mains was designed, with a neutral conductor equal to the combined capacity of the two outside conductors, so that 120-volt two-wire generators could be utilized without any change in the feeders.

Basement. The plan of the basement, Fig. 35, shows the branch circuit wiring for the outlets in the basement, and the location of the main switchboard. It also shows the trunk cables for the interconnection system serving to provide the necessary wires for telephones, tickers, messenger calls, etc., in all the rooms throughout the building, as will be described later.

To avoid confusion, the feeders were not shown on the basement



FEEDERS

NO.	END AT: FLOOR	END AT: CUT-OUT	BRANCH CIR.	LIGHTS	LENGHT-FT (ONE WAY)	LOSS IN VOLTS	SIZE OF WIRE: NO. MIDDLE COND'R	SIZE OF WIRE: NO. OUTSIDE COND'R	INSIDE DIA. OF CONDUIT ALLOWED *
1	BASMT	A	18	115	48	0.84	2	4	1.25"
2	1 ST	"	83	533	88	1.18	400000	4-0	2.5"
3	3 RD	"	43	288	119	1.68	4-0	0	2"
4	5 TH	"	44	296	147	1.78	250000	2-0	2.5"
5	7 TH	"	"	292	173	1.72	300000	3-0	"
6	9 TH	"	124	365	200	1.61	450000	250000	3"
7	3 RD	B	26	131	119	1.5	0	3	1.5"
8	8 TH	"	27	128	185	1.8	2-0	2	2"
L-S	SW.B	"		2165	138	1.5	4000000	2000000	***
9	2 ND	D			148		400000		3"
10	PRESS				83		700000		**
11	"				118		"		"
12	"				"		"		"
13	PASS.ELV.				58		4-0		2"
14	"				"		"		"
15	"				"		"		"
16	FRGT ELV.				148		"		"
P-S	SW.B				138		2000000		****

* ALL CONDUCTORS IN ONE CONDUIT.
** SEPARATE CONDUIT FOR EACH CONDUCTOR
*** THIS FEEDER IS TO BE DIVIDED INTO FOUR (4)
" CONDUCTORS OF #2000000 C.M. EACH.
" EACH CONDUCTOR IS TO BE INSTALLED IN A SEP-
" ARATE 3" (INSIDE DIAM.) CONDUIT
L.S.=LIGHTING SUPPLY
P.S.=POWER "
**** SEPARATE 3" (INSIDE DIAM.) CONDUIT FOR EACH
" CONDUCTOR

MAINS

MAINS	SUPPLIED BY: FEEDER #	SUPPLIED BY: CUT OUT	SUPPLIED BY: FLOOR	LIGHTS	LENGTH-FT (ONE WAY)	LOSS IN VOLTS	SIZE OF WIRE: NO. MIDDLE COND'R	SIZE OF WIRE: NO. OUTSIDE COND'R	INSIDE DIA. OF CONDUIT ALLOWED *
A-2	2	A	1 ST	284	63	0.72	250000	2-0	2.5"
A-4	3	"	3 RD	147	18	0.41	2	4	1.25"
A-6	4	"	5 TH	146	"	0.4	"	"	"
A-8	5	"	7 TH	"	"	"	"	"	"
A-10	6	"	9 TH	171	"	0.29	0	3	1.5"
B-1	2	"	1 ST	76	70	0.51	"	"	"
B-2	"	"	"	206	58	0.58	4-0	0	2"
B-10	6	"	10 TH	87	44	0.37	0	3	1.5"
D-1	2	"	1 ST	120	12	0.22	2	4	1.25"
C-1	"	"	"	70	44	0.30	0	3	1.5"
F-1	7	C	2 ND	22	61	0.41	8	10	1"
C-2	"	B	3 RD	47	18	0.52	"	"	"
B-4	"	"	"	56	"	0.60	"	"	"
B-5	"	"	4 TH	28	"	0.31	"	"	"
B-6	8	"	7 TH	32	"	0.35	"	"	"
B-7	"	"	8 TH	56	"	0.60	"	"	"
B-9	"	"	"	44	"	0.48	"	"	"
C-10	"	"	9 TH	16	"	0.28	10	12	"
E-1	2	A	1 ST	61	92	0.86	2	4	1.25"
E-2	9	D	2 ND		84		0	0	1.5"
D-10	"	"	"		108		2	2	1.25"

* ALL CONDUCTORS IN ONE CONDUIT

MOTOR CIRCUITS

NO.	SUPPLIED BY: FEEDER	SUPPLIED BY: CUT OUT	SUPPLIED BY: FLOOR	H.P. SUPPLIED	CURRENT IN AMP.	LENGTH IN FEET (ONE WAY)	SIZE OF WIRE	INSIDE DIAM. OF CONDUIT ALLOWED *
1			BSMT	15	60	74	2	1.25"
2			"	"	"	"	"	"
3			"	5	20	50	8	1"
4			"	"	"	40	"	"
5			"	15	60	"	2	1.25"
6			"	3	12	48	10	0.75"
7			"		20	"	8	1"
8			"	15	60	80	2	1.25"
9	MAIN		"	"	"	"	"	"
10	D-10	D	10 TH	7.5	30	134	6	1"
11	"	"	"	"	"	28	"	"

* BOTH CONDUCTORS IN ONE CONDUIT

CUT-OUTS

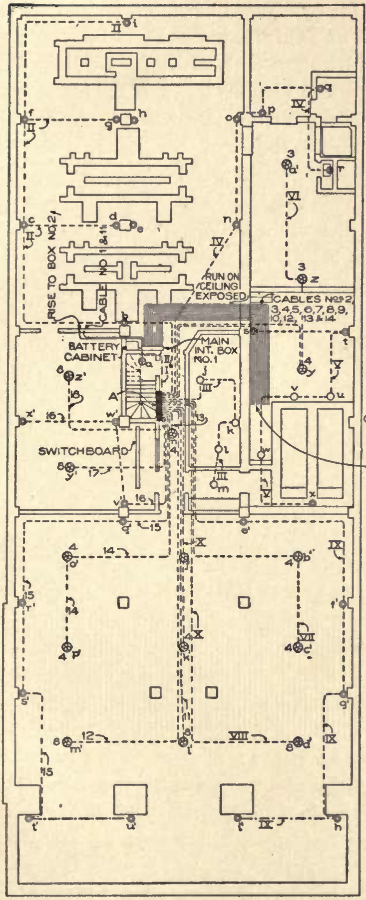
NAME	FLOOR	MAINS	BRANCH CIRCUITS	P.B. SWITCHES	METERS	KNIFE SWITCHES T.P.S.T. 25 AMP.	T.P.S.T. 50 "	T.P.S.T. 100 "	T.P.S.T. 150 "	T.P.S.T. 200 "	D.P.S.T. 25 "	D.P.S.T. 50 "	D.P.S.T. 100 "	D.P.S.T. 125 "	D.P.S.T. 150 "
A	BSMT		20	10											
"	1 ST	4					2	1		1					
B	"		10	10											
C	"		"	"											
D	"	1	12	8			2								
E	"		"	4											
F	"		8	6											
A	2 ND	1	16	1			1*		1						
B	"		32	3											
C	"	1	4	4		2									
D	"	1									24		1	1	
E	"										4	6			
A	3 RD	1	22	1				2							
B	"	2	4	4		3									
A	4 TH		24	1											
B	"	1	4	4		2									
A	5 TH	1	24	1				2							
B	"		4	4											
A	6 TH		28	1											
B	"		4	4											
A	7 TH	1	24	1				2							
B	"	1	4	4		2									
A	8 TH		24	1											
B	"	2	4	4		3									
A	9 TH	1	24	1				1*	1						
B	"	1	4	4		2									
A	10 TH	1	24	1			1*	1							
B	"		16	1											
C	"		4	4											
D	"										4	2			

* MAIN SWITCH

Fig. 34. Wiring of an Office Building. Diagram Showing Arrangement of Feeders and Mains Cut-Out Centers, etc.

SCENE FROM PHOTOPLAY, "BACK TO THE PRIMITIVE"
Courtesy of *Selig Polyscope Co., Inc., Chicago*

FOLCHETTO DECLARES HIS LOVE
Scene from Pathé film, "Undying Love"
Courtesy of *Pathé Frères, New York and Paris*



SCHEDULE OF CIRCUITS

NO.	SUPPLIED by CUTOUT	SUPPLIED by MAIN	No. of BRANCHES	OUTLETS SUPPLIED	TOTAL OUTLETS	TOTAL LIGHTS	AT WHAT POINT CONTROLLED
I	A	FDR NO-1	1	a	1	1	
II	"	"	3	bcdefghi	8	8	
III	"	"	1	jklm	4	4	
IV	"	"	1	nopqr	5	5	
V	"	"	1	stuvwx	6	6	
VI	"	"	1	yza'	3	10	S at A
VII	"	"	1	b'c'	2	8	" " "
VIII	"	"	1	d'	1	8	" " "
IX	"	"	1	e'f'g'h'i'	5	5	
X	"	"	1	j'k'	2	8	S at A
11	"	"	1	l'	1	8	" " "
12	"	"	1	m'	1	8	" " "
13	"	"	1	n'	1	4	" " "
14	"	"	1	o'p'	2	8	" " "
15	"	"	1	q'r's't'u'	5	5	
16	"	"	1	v'w'x'	3	3	
17	"	"	1	y'	1	8	S at A
18	"	"	1	z'	1	8	" " "
					52	115	

CABLE	NO. 2	RISES	TO	2nd	FLOOR
"	" 3	"	"	3rd	"
"	" 4	"	"	4th	"
"	" 5	"	"	5th	"
"	" 6	"	"	6th	"
"	" 7	"	"	7th	"
"	" 8	"	"	8th	"
"	" 9	"	"	9th	"
"	" 10	"	"	10th	"
"	" 12	"	"	2nd	"
"	" 13	"	"	5th	"
"	" 14	"	"	8th	"

Key Showing Explanation of Various Symbols used in Figs. 41 to 46 Inclusive

- --------Ceiling Chandelier
- --------Wall Bracket
- --------Gooseneck Bracket
- --------Wall Socket
- --------Drop Cord
- --------Arc Lamp
- --------Cooper-Hewitt Lamp
- --------Cluster
- --------Floor Outlet
- --------Desk Light
- --------Extension Outlet
- --------Push Button Switch
- --------Snap Switch
- --------Junction Box
- --------Electric Clock
- --------Master Clock
- --------Motor Starter
- --------CutOut Panel
- --------Interconnection Box
- --------Power Panel
- --------Pull Box
- --------Circuit under Floor
- " " " above
- " on Ceiling Exposed
- --------Service Line under Floor

Fig. 35. Wiring an Office Building. Basement Plan Showing Branch Circuit Wiring for Outlets in Basement, Location of Main Switchboard, and Trunk Cables of the Interconnection System Providing Wires for Telephone, Ticker, and Messenger Call Service, etc.

plan, but were described in detail in the specification, and installed in accordance with directions issued at the time of installation. The electric current supply enters the building at the front, and a service switch and cut-out are placed on the front wall. From this point, a two-wire feeder for power and a three-wire feeder for lighting, are run to the main switchboard located near the center of the basement. Owing to the size of the conduits required for these supply feeders, as well as the main feeders extending to the upper floors of the building, the said conduits are run exposed on substantial hangers suspended from the basement to the ceiling.

First Floor. The rear portion of the building from the basement through the first floor, and including the mezzanine floor, between the first and second floors, at the rear portion of the building only, is utilized as a press room for several large and heavy modern newspaper presses. The motors and controllers for these presses are located on the first floor. A separate feeder for each of these press motors is run directly from the main switchboard to the motor controller in each case. Empty conduits were provided, extending from the controllers to the motor in each case, intended for the various control wires installed by the contractor for the press equipments.

One-half of the front portion of the first floor is utilized as a newspaper office; the remaining half, as a bank.

Second Floor. The rear portion of the second floor is occupied as a composing and linotype room, and is illuminated chiefly by means of drop-cords from outlets located over the linotype machines and over the compositors' cases. Separate $\frac{1}{8}$-horse-power motors are provided for each linotype machine, the circuits for the same being run underneath the floor.

Upper Floors. The upper floors are similar in all respects with the exception of certain changes in partitions, which are not material for the purpose of illustration or for practical example. The circuit work is sufficiently intelligible from the plan to require no further explanation.

Interconnection System. In the interconnection system, the main interconnection box is located in the basement; adjoining this main box is located the terminal box of the local telephone company. A separate system of feeders is provided for the ticker system, as these conductors require somewhat heavier installation, and it was thought inadvisable to place them in the same conduits with the telephone wires, owing to the higher potential of ticker circuits. A separate interconnection cable runs to each floor, for telephone and messenger call purposes; and a central box is placed near the rising point at each floor, from which run subsidiary cables to several points symmetrically located on the various floors. From these subsidiary boxes, wires can be run to the various offices requiring telephone or other service. Small pipes are provided to serve as raceways from office to office, so as to avoid cutting partitions. In this way, wires can be quickly provided for any office in the building without damaging the building in any way whatever; and, as provision is made for a special wooden moulding near the ceiling to accommodate these wires, they can be run around the room without disfiguring the walls. All the main cables and subsidiary wires are connected with special interconnection blocks numbered serially; and a schedule is provided in the main interconnection box in the basement, which enables any wire originating thereat, to be readily and conveniently traced though the building. All the main cables and subsidiary cables are run in iron conduits.

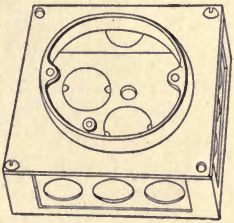


Fig. 36. Universal and Knock Out Type of Outlet Box

OUTLET-BOXES, CUT-OUT PANELS, AND OTHER ACCESSORIES

Outlet Boxes. Before the introduction of iron conduits, outlet-

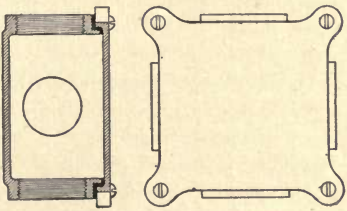


Fig. 37. Water-Tight Outlet Box

boxes were considered unnecessary, and with a few exceptions were not used, the conduits being brought to the outlet and cut off after the walls and ceilings were plastered. With the introduction of iron conduits, however, the necessity for outlet-boxes was realized; and the *Rules of the Fire Underwriters* were modified so as to require their use. The *Rules of the National Electric Code* now require outlet-boxes to be used with rigid iron and flexible steel conduits, and with armored cables. A portion of the rule requiring their use is as follows:

All interior conduits and armored cables must be equipped at every outlet with an approved outlet-box or plate.

Outlet-plates must not be used where it is practicable to install outlet-boxes.

In buildings already constructed, where the conditions are such that neither outlet-box nor plate can be installed, these appliances may be omitted by special permission of the inspection department having jurisdiction, providing the conduit ends are bushed and secured.

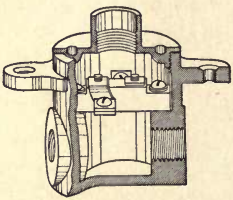


Fig. 38.

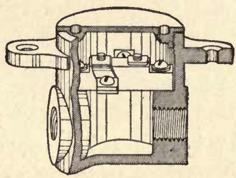


Fig. 39.

Types of Floor Outlet Boxes

Fig. 36 shows a typical form of outlet-box for bracket or ceiling outlets of the *universal type*. When it is desired to make an opening for the conduits, a blow from a hammer will remove any of the weakened portion of the wall of the outlet-box, as may be required. This form of outlet-box is frequently referred to as the *knock-out type*. Other forms of outlet-boxes are made with the openings cast in the box at the required points, this class being usually stronger and better made than the universal type. The advantages of the universal type of outlet-box are that one form of box will serve for any ordinary conditions, the openings being made according to the number of conduits and the directions in which they enter the box.

Fig. 37 shows a waterproof form of outlet-box used out of doors, or in other places where the conditions require the use of a watertight and waterproof outlet-box.

It will be seen in this case, that the box is threaded for the conduits, and that the cover is screwed on tightly and a flange provided for a rubber gasket.

Figs. 38 and 39 show water-tight floor boxes which are for outlets located in the floor. While the rules do not require that the floor outlet

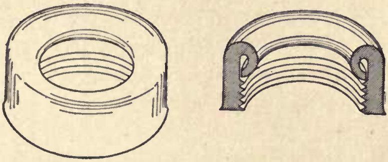


Fig. 40. Conduit Bushing

box shall be water-tight, it is strongly recommended that a water-tight outlet be used in all cases for floor connections. In this case also, the conduit opening is threaded, as well as the stem cover through which the extension is made in the conduit to the desk or table. When the floor outlet connection is not required, the stem cover may be removed and a flat blank cover be used to replace the same.

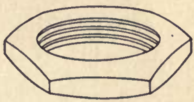


Fig. 41. Lock-Nut

There is hardly any limit to the number and variety of makes of outlet-boxes on the market, adapted for ordinary and for special conditions; but the types here illustrated are characteristic and typical forms.

Bushings. The *Rules of the National Electric Code* require that conduits entering junction-boxes, outlet-boxes, or cut-out cabinets

Fig. 42. Panel-Box Terminal Bushing

shall be provided with approved *bushings,* fitted to protect the wire from abrasion.

Fig. 40 shows a typical form of conduit bushing. This bushing is screwed on the end of the conduit after the latter has been introduced into the outlet-box, cut-out cabinet, etc., thereby forming an insulated orifice to protect the wire at the point where it leaves the conduits, and to prevent abrasion, grounds, short circuits, etc. A lock-nut, Fig. 41, is screwed on the threaded end of the conduit before the conduit is placed in the outlet-box or cut-out cabinet, and this lock-nut and bushing clamp the conduit securely in position. Fig. 42 shows a terminal bushing for panel-boxes used for flexible steel conduit or armored cable.

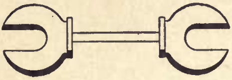


Fig. 43 Copper-Tipped Fuse Link

The *Rules of the National Electric Code* require that the metal of conduits shall be permanently and effectually grounded, so as to insure a positive connection for grounds or leaking currents, and in order to provide a path of least resistance to prevent the current from finding a path through any source which might cause a fire. At outlet-boxes, the conduits and gas pipes must be fastened in such a manner as to insure good electrical connection; and at centers of distribution, the conduits should be joined by suitable bond wires, preferably of copper, the said bond wires being connected to the metal structure of the building, or, in case of a building not having an iron or steel structure, being grounded in a permanent manner to water or gas-piping.

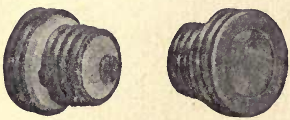


Fig. 44. Edison Fuse-Plug

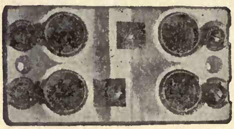


Fig. 45. Porcelain Cut-Out Block

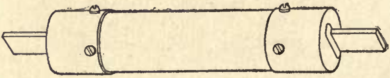


Fig. 46. Enclosed or "Cartridge" Fuse

Fuse-Boxes, Cut-Out Panels, etc. From the very outset, the necessity was apparent of having a protective device in circuit with the conductor to protect it from overload, short circuits, etc. For this purpose, a fusible metal having a low melting point was employed. The form of this fuse has varied greatly. Fig. 43 shows a characteristic form of what is known as the *link fuse* with copper terminals, on which is stamped the capacity of the fuse.

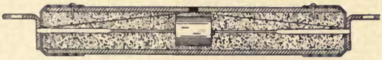


Fig. 47. Section of Enclosed Fuse

The form of fuse used probably to a greater extent than any other, although it is now being superseded by other more modern forms, is that known as the *Edison fuse-plug*, shown in Fig. 44. A porcelain *cut-out block* used with the Edison fuse is shown in Fig. 45.

Within the last four or five years, a new form of fuse, known as the *enclosed fuse*, has been introduced and used to a considerable

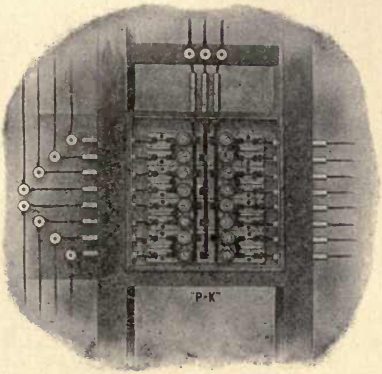


Fig. 48. Porcelain Cut-Outs in Wooden Box

extent. A fuse of this type is shown in Fig. 46. Fig. 47 gives a sectional view of this fuse, showing the porous filling surrounding the fuse-strips, and also the device for indicating when the fuse has blown. This form of fuse is made with various kinds of terminals; it can be used with spring clips in small sizes, and with a post screw contact in larger sizes. For ordinary low potentials this fuse is desirable for currents up to 25 amperes; but it is a debatable question

TABLE VI

Carrying Capacity of Wires

B. & S. Gauge	Circular Mils	Rubber Insulation	Other Insulation
		Amperes	Amperes
18	1,624	3	5
16	2,583	6	8
14	4,107	12	16
12	6,530	17	23
10	10,380	24	32
8	16,510	33	46
6	26,250	46	65
5	33,100	54	77
4	41,740	65	92
3	52,630	76	110
2	66,370	90	131
1	83,690	107	156
0	105,500	127	185
00	133,100	150	220
000	167,800	177	262
0000	211,600	210	312
	200,000	200	300
	300,000	270	400
	400,000	330	500
	500,000	390	590
	600,000	450	680
	700,000	500	760
	800,000	550	840
	900,000	600	920
	1,000,000	650	1,000
	1,100,000	690	1,080
	1,200,000	730	1,150
	1,300,000	770	1,220
	1,400,000	810	1,290
	1,500,000	850	1,360
	1,600,000	890	1,430
	1,700,000	930	1,490
	1,800,000	970	1,550
	1,900,000	1,010	1,610
	2,000,000	1,050	1,670

whether it is desirable to use an enclosed fuse for heavier currents. Fig. 48 shows a *cut-out box* with Edison plug fuse-blocks used with knob and tube wiring. It will be seen that there is no connection compartment in this fuse-box, as the circuits enter directly opposite the terminals with which they connect.

Table VI shows the allowable carrying capacity of copper wires and cables of ninety-eight per cent conductivity, according to the standard adopted by the American Institute of Electrical Engineers and must be followed in placing interior conductors.

For insulated aluminum wire the safe-carrying capacity is 84 per cent of that given for copper wire with the same kind of insulation.

The lower limit is specified for rubber-covered wires to prevent gradual deterioration of the high insulations by the heat of the wires, but not from fear of igniting the insulation. The question of drop is not taken into consideration in the above tables.

The carrying capacity of Nos. 16 and 18, B. & S. gauge wire is given, but no smaller than No. 14 is to be used, except as allowed under rules for fixture wiring.

ARC LAMPS

Electric Arc. Suppose two carbon rods are connected in an electric circuit, and the circuit closed by touching the tips of these rods together; on separating the carbons again the circuit will not be broken, provided the space between the carbons be not too great but will be maintained through the arc formed at these points. This phenomenon, which is the basis of the arc light, was first observed on a large scale by Sir Humphrey Davy, who used a battery of 2,000 cells and produced an arc between charcoal points 4 inches apart.

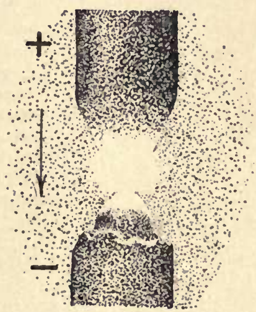


Fig. 49. The Electric Arc Between Carbon Terminals

As the incandescence of the carbons across which an arc is maintained, together with the arc itself, forms the source of light for a large portion of arc lamps, it will be well to study the nature of the arc. Fig. 49 shows the general appearance of an arc between two carbon electrodes when maintained by direct current.

Here the current is assumed as passing from the top carbon to the bottom one as indicated by the arrow and signs. We find, in the direct-current arc, that the most of the light issues from the tip of the positive carbon, or electrode, and this portion is known as the *crater* of the arc. This crater has a temperature of from 3,000° to 3,500° C., the temperature at which the carbon vaporizes, and gives fully 80 to 85 per cent of the light furnished by the arc. The negative carbon becomes pointed at the same time that the positive one is hollowed out to form the crater, and it is also incandescent but not to as great a degree as the positive carbon. Between the electrodes there is a band of violet light, the *arc proper,* and this is surrounded by a lu-

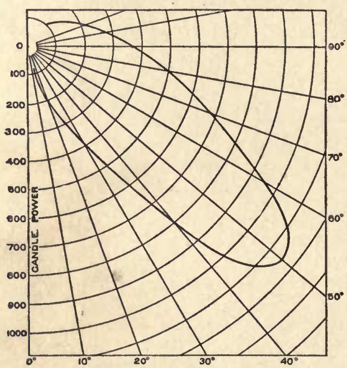


Fig. 50. Distribution Curve for D. C. Arc Lamp (Vertical Plane)

minous zone of a golden yellow color. The arc proper does not furnish more than 5 per cent of the light emitted when pure carbon electrodes are used.

The carbons are worn away or consumed by the passage of the current, the positive carbon being consumed about twice as rapidly as the negative.

The light distribution curve of a *direct-current arc,* taken in a vertical plane, is shown in Fig. 50. Here it is seen that the maximum amount of light is given off at an angle of about 50° from the vertical, the negative carbon shutting off the rays of light that are thrown directly downward from the crater.

If alternating current is used, the upper carbon becomes positive and negative alternately, and there is no chance for a crater to be formed, both carbons giving off the same amount of light and being consumed at about the same rate. The light distribution curve of an *alternating-current arc* is shown in Fig. 51.

Arc-Lamp Mechanisms. In a practical lamp we must have not only a pair of carbons for producing the arc, but also means for sup-

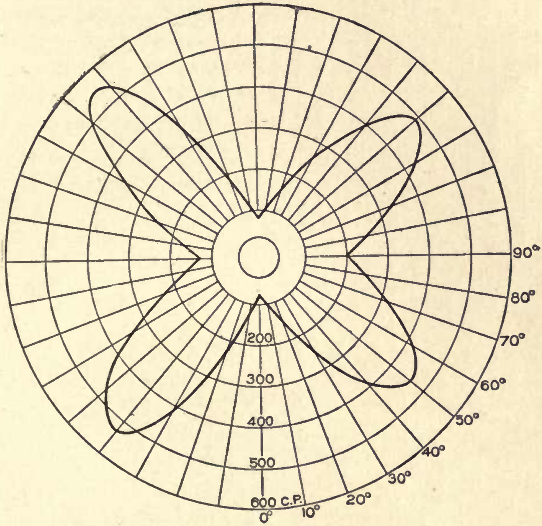


Fig. 51. Distribution Curve for A. C. Arc Lamp (Vertical Plane)

porting these carbons, together with suitable arrangements for leading the current to them and for maintaining them at the proper distance apart. The carbons are kept separated the proper distance by the operating mechanisms which must perform the following functions:

1. The carbons must be in contact, or be brought into contact, to start the arc when the current first flows.
2. They must be separated at the right distance to form a proper arc immediately afterward.
3. The carbons must be fed to the arc as they are consumed.
4. The circuit should be open or closed when the carbons are entirely consumed, depending on the method of power distribution.

The feeding of the carbons may be done by hand, as is the case in some stereopticons using an arc, but for ordinary illumination the striking and maintaining of the arc must be automatic. It is made so in all cases by means of solenoids acting against the force of gravity or against springs. There is an endless number of such mechanisms, but a few only will be described here. They may be roughly divided into three classes: shunt mechanisms, series mechanisms, differential mechanisms.

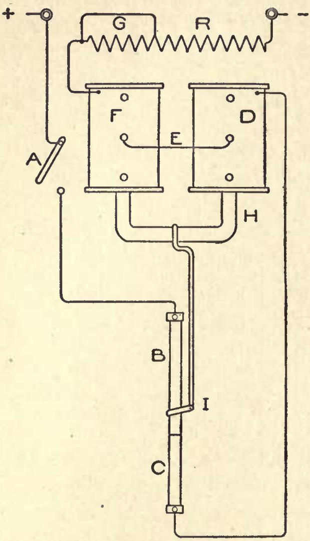


Fig. 52. Series Mechanism for D. C. Arc Lamp

Shunt Mechanisms. In shunt lamps, the carbons are held apart before the current is turned on, and the circuit is closed through a solenoid connected in across the gap so formed. All of the current must pass through this coil at first, and the plunger of the solenoid is arranged to draw the carbons together, thus starting the arc. The pull of the solenoid and that of the springs are adjusted to maintain the arc at its proper length.

Such lamps have the disadvantage of a high resistance at the start—450 ohms or more—and are difficult to start on series circuits, due to the high voltage required. They tend to maintain a constant voltage at the arc, but do not aid the dynamo in its regulation, so that the arcs are liable to be a little unsteady.

Series Mechanisms. With the series-lamp mechanism the carbons are together when the lamp is first started and the current, flowing in the series coil, separates the electrodes, striking the arc. When the arc is too long, the resistance is increased and the current lowered, so that the pull of the solenoid is weakened and the carbons feed together. This type of lamp can be used only on constant-potential systems.

Fig. 52 shows a diagram of the connection of such a lamp. This diagram is illustrative of the connection of one of the lamps manufactured by the Western Electric Company, for use on a direct-current, constant-potential system. The symbols + and − refer to the terminals of the lamp, and the lamp must be so connected that the current flows from the top carbon to the bottom one. *R* is a series resistance, adjustable for different voltages by means of the shunt *G*. *F* and *D* are the controlling solenoids connected in series with the arc. *B* and *C* are the positive and negative carbons respectively, while *A* is the switch for turning the current on and off. *H* is the plunger of the solenoids and *I* the carbon clutch, this being what is known as a *carbon-feed lamp*. The carbons are together when *A* is first closed, the current is excessive, and the plunger is drawn up into the solenoids, lifting the carbon *B* until the resistance of the arc lowers the current to such a value that the pull of the solenoids just counter-balances the weight of the plunger and carbon. *G* must be so adjusted that this point is reached when the arc is at its normal length.

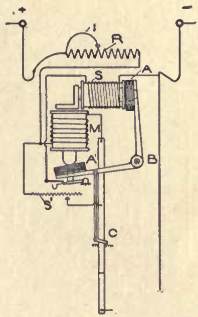


Fig. 53. Differential Mechanism for D. C. Arc Lamp

Differential Mechanisms. In the differential lamp, the series and shunt mechanisms are combined, the carbons being together at the start, and the series coil arranged so as to separate them while the shunt coil is connected across the arc, as before, to prevent the carbons from being drawn too far apart. This lamp operates only over a low-current range, but it tends to aid the generator in its regulation.

Fig 53 shows a lamp having a differential control, this also being the diagram of a Western Electric Company arc lamp for a direct-current, constant-potential system. Here *S* represents the shunt coil and *M* the series coil, the armature of the two magnets *A* and *A′* being attached to a bell-crank, pivoted at *B*, and attached to the carbon clutch *C*. The pull of coil *S* tends to lower the carbon while that of *M* raises the carbon, and the two are so adjusted that equilibrium is reached when the arc is of proper length. All of the lamps are fitted with an air *dashpot*, or some damping device, to prevent too rapid movements of the working parts.

The methods of supporting the carbons and feeding them to the arc may be divided into two classes: rod-feed mechanism, carbon-feed mechanism.

Rod-Feed Mechanism. Lamps using a rod-feed have the upper carbons supported by a conducting rod, and the regulating mechanism acts on this rod, the current being fed to the rod by means of sliding contact. Fig. 54 shows the arrangement of this type of feed. The rod is shown at *R*, the sliding contact at *B*, and the carbon is attached to the rod at *C*.

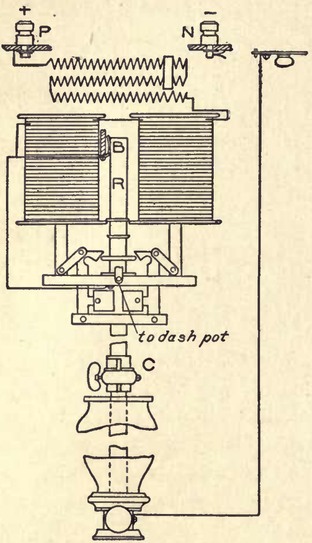


Fig. 54. Rod-Feed Mechanism

These lamps have the advantage that carbons, which do not have a uniform cross-section or smooth exterior, may be used, but they possess the disadvantage of being very long in order to accommodate the rod. The rod must also be kept clean so as to make a good contact with the brush.

Carbon-Feed Mechanism. In carbon-feed lamps the controlling mechanism acts on the carbons directly through some form of clutch which grips the carbon when it is lifted, but allows the carbon to slip through it when the tension is released. For this type of feed the carbon must be straight and have a uniform cross-section as well as a smooth exterior. The current may be led to the carbon by means of a flexible lead and a short carbon holder.

MOVING-PICTURE MACHINES

Arc Lamp. Arc lamp used as a part of moving picture machines must be constructed similar to arc lamps of theaters, and wiring of same must not be of less capacity than No. 6 B. & S. gauge.

Arc lamps used for stage effects must conform to the following requirements:

a. Must be constructed entirely of metal except where the use of *approved* insulating material is necessary.

b. Must be substantially constructed, and so designed as to provide for proper ventilation, and to prevent sparks being emitted from lamps when same is in operation, and mica must be used for frame insulation.

c. Front opening must be provided with a self-closing hinged door frame in which wire gauze or glass must be inserted, excepting lens lamps, where the front may be stationary, and a solid door be provided on back or side.

d. Must be provided with a one-sixteenth-inch iron or steel guard having a mesh not larger than 1 inch, and be substantially placed over top and upper half of sides and back of lamp frame; this guard to be substantially riveted to frame of lamp, and to be placed at a distance of at least 2 inches from the lamp frame.

e. Switch on standard must be so constructed that accidental contact with any live portion of same will be impossible.

f. All stranded connections in lamp and at switch and rheostat must be provided with approved lugs.

g. Rheostat, if mounted on standard, must be raised to a height of at least 3 inches above floor line, and in addition to being properly enclosed must be surrounded with a substantially attached metal guard having a mesh not larger than 1 square inch, which guard is to be kept at least 1 inch from outside frame of rheostat.

h. A competent operator must be in charge of each arc lamp, except that one operator may have charge of two lamps when they are not more than 10 feet apart, and are so located that he can properly watch and care for both lamps.

Miscellaneous. *Rheostats* must conform to rheostat requirements for theater arcs.

Top reel must be encased in a steel box with a hole at the bottom only large enough for film to pass through, and cover so arranged that this hole can be instantly closed. No solder to be used in the construction of this box.

A *steel box* must be used, for receiving the film after being shown, with a hole in the top only large enough for the film to pass through freely, with a cover so arranged that this hole can be instantly closed. An opening may be placed at the side of the box to take the film out, with a door hung at the top, so arranged that it cannot be entirely opened, and provided with spring catch to lock it closed. No solder to be used in the construction of this box.

The *handle* or crank used in operating the machine must be secured to the spindle or shaft, so that there will be no liability of its coming off and allowing the film to stop in front of lamp.

A *shutter* must be placed in front of the condenser, arranged so as to be readily closed.

Extra films must be kept in metal box with tight-fitting cover.

Machines must be operated by hand (motor driven will not be permitted).

Picture machine must be placed in an enclosure or house made of suitable fireproof material, be thoroughly ventilated and large enough for operator to walk freely on either side of or back of machine. All openings into this booth must be arranged so as to be entirely closed by doors or shutters constructed of the same or equally good fire-resisting material as the booth itself. Doors or covers must be arranged so as to be held normally closed by spring hinges or equivalent devices.

*MERCURY-ARC RECTIFIERS FOR MOTION PICTURES

One of the most important factors contributing to the success of a motion-picture theater is the quality and brilliancy of the light projected from the lamps. For pleasing effect motion pictures require a steady, white light of sufficient intensity to bring out the natural light and color values of the films, and the theater having the best quality of light stands the best show of getting the biggest patronage. It is well known that the light obtained from the direct-current is much superior to that from the alternating-current arc lamps. However, until recently all those who could obtain only alternating-current supply have got along with the poorer quality of light simply for the lack of apparatus for economically converting alternating current into direct current.

In Fig. 55 is shown a mercury-arc rectifier developed by the General Electric Company for furnishing current of the desired character at a cost less than that of the most economically operated alternating-current arc lamp.

There are certain facts which should be borne in mind while making an analysis of the cost of producing a given intensity of projected light from alternating current, direct current, and rectified

*By courtesy of the McGraw Publishing Company.

A LETTER FROM HIS MOTHER
Scene from Photoplay, "Col. E. D. Baker—1st Cal."
Courtesy of the *Champion Film Company, New York*

SCENE FROM "AT THE OLD MILL," BY ECLIPSE
A Simple Rustic Drama of Indescribable Beauty
Courtesy of the *Kleine Optical Co., Chicago*

current with the most approved devices applicable in each case. For instance, the best class of motion pictures requires a light intensity of upward of 8,000 candle power, and as 5,000 candle power is the maximum obtainable from alternating current with the best auto-transformers, or the highest current values practicable, it is evident that the use of alternating current under such conditions is

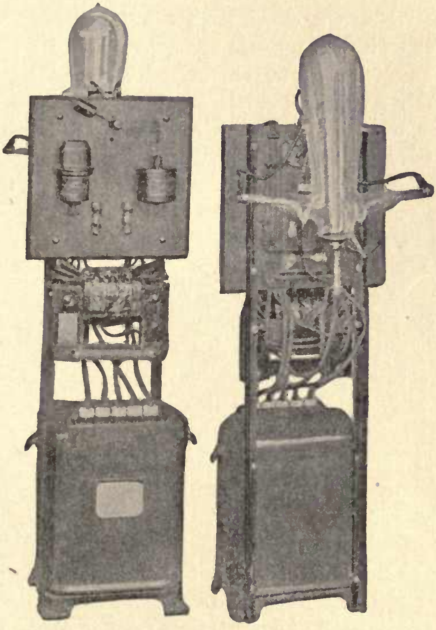


Fig. 55. Front and Back Views of Mercury-Arc Rectifier for Moving-Picture Machine

entirely satisfactory owing to the insufficiency of the light. Where direct-current supply is obtainable, some have found relief by using it, but their experience has served to emphasize the prohibitory effect of the additional cost entailed by the loss of at least 60 per cent of the energy drawn from the line in the resistance or rheostat employed to regulate the current in the arc.

These facts serve to define the limitations of both the alternating-current and the direct-current arc relative to motion-picture lighting, but in order to give the various alternating-current methods a fair basis for comparison, assume that a light intensity of 5,000 candle power is required. From actual determinations carefully made it is found that to obtain 5,000 candle power from a 110-volt alternating-current circuit with rheostats requires 7 kilowatts; a 110-volt direct-current circuit with rheostat requires 2.25 kilowatts; any alternating-current circuit with auto-transformer requires 2.1 kilowatts, and with mercury-arc rectifier requires 1.7 kilowatts.

Since auto-transformers are extensively used in alternating-current supply systems to obtain a substantial reduction in energy consumption, the method of using alternating current with rheostats may be considered as obsolete, and since a prohibitory amount of energy is wasted in using direct current with a rheostat, that method can be omitted from present consideration. This affords a direct comparison between the alternating current with the use of economizers on the one hand and mercury-arc rectifiers on the other.

The figures given above show a difference of 400 watts in favor of the mercury-arc rectifier. This means than on the basis of an average daily run of seven hours at a cost of 6 cents a kilowatt-hour the use of a mercury-arc rectifier provides a light having all the advantages of that given by a direct-current arc at a cost of at least $60 per year less than that obtained from alternating current with the best type of auto-transformer.

Furthermore, it is evident that when the light intensity required exceeds 5,000 candle power, thus rendering the alternating-current method inapplicable, the saving effected by the use of the mercury-arc rectifier as compared to the cost of using direct current with a rheostat is much more significant. For instance, to obtain 7,500 candle power requires 3.1 kilowatts from direct current with rheostat and 2.15 kilowatts from alternating current with mercury-arc rectifier. The difference in favor of the mercury-arc rectifier is 950 watts, which means a saving of at least $145 per year.

In addition to the positive money-saving capability of the device, the excellent light of practically any candle-power obtainable from alternating-current supply and the reliability, ease, and safety of operation render the mercury-arc rectifier particularly desirable for making pleasing and successful "photo plays."

REVIEW QUESTIONS

REVIEW QUESTIONS

ON THE SUBJECT OF

PHOTOGRAPHY

1. What are the three very general divisions or steps in making photographs?

2. How would you focus a camera upon a subject to be photographed?

3. What is meant by the *focal length* of a lens?

4. How would you measure or estimate the focal length of a lens?

5. Name more than one kind of aberration in a photographic lens which may be "corrected" by proper lens construction.

6. Name more than one kind of camera shutter.

7. What is a photographic darkroom?

8. What is the routine of camera manipulation to make a photographic exposure on the glass sensitive plate?

9. Seven points were given in the text for care in arranging the image upon the ground glass. Name at least four of them.

10. The image having been arranged upon the ground glass, how is it recorded to form a negative?

11. What means are available for estimating the length of an exposure, after the camera is ready?

12. How does changing the size of the diaphragm opening affect the exposure?

13. What is meant by *development?*

14. Name more than one method of development.

15. Describe one method of development, including fixing and washing the negative.

16. What is meant by *red lamp, ruby lamp,* or *safe light?*

17. What is meant by *printing?*

18. Describe one process of printing.

19. What differences can you mention between a lantern slide and an ordinary photograph?

20. What is a stereograph?

21. Define *telephotography*.

22. Explain the use of autochrome plates.

REVIEW QUESTIONS

ON THE SUBJECT OF

MOTOGRAPHY

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1. Name some of the classes of motion-picture subjects as classified by the nature of the subject.

2. What divisions of labor are made in the producing of commercial motion pictures for amusement purposes?

3. What is the nature of a motion-picture drama?

4. What is the requirement of a motion-picture comedy?

5. What is a scrip? Describe how it is written.

6. What are the duties of a producer?

7. What is the order of work in producing a drama?

8. How are indoor studios lighted?

9. What are the property man's duties?

10. What is a "lecture" and how is it written?

11. What are the necessary divisions of the photographic factory for motion pictures?

12. How is raw strip film made before its purchase by the motion-picture factory?

13. What are the proper dimensions for film strip, pictures, and sprocket holes?

14. Name several of the features which a good motion-picture camera should have.

15. How is a camera man able to regulate the photographic exposure value of the light upon the film?

16. How is a 200-foot motion-picture film developed and printed?

17. When and how are title negatives made for a motion picture?

18. Describe one process of making a title.

19. Name the two kinds of printing machines. Describe one of them briefly.

20. Describe the processes of staining a film, and of toning, or monochroming, a film.

21. Describe the different processes of coloring films.

REVIEW QUESTIONS

ON THE SUBJECT OF

MOTION-PICTURE THEATER

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1. In studying a theater, what points should a manager notice?

2. In studying a theater with a view to purchase, what points should be studied?

3. Name a few of the "side lines" possible in managing a motion-picture theater to add to the ticket-window income.

4. When should "side lines" be avoided in managing a theater?

5. What are the steps to be taken in starting a new theater?

6. In studying the location of a new theater among existing competing theaters, how is the probable income of the proposed theater estimated?

7. In studying a theater location in unoccupied city territory, how is the probable income of the proposed theater estimated.

8. In a small town, how is the probable income of a small theater estimated?

9. How would you try to raise the money to start a theater?

10. What is meant by the "program" of a motion-picture theater?

11. What is a *sloping floor* and what are its advantages?

12. In what two ways may a sloping floor be put in?

13. Describe a good cheap picture screen.

14. Describe the *mirror screen.*

15. Describe an *airdome.*

16. What means has the theater manager for advertising his theater?

17. What is a *feature film?*

18. How may a feature film be advertised?

19. Describe a "special program," either describing one of the kinds mentioned in the textbook, or devise a new special program yourself and describe it.

20. How would you proceed, as manager, to get a good contract with a film exchange?

21. What precautions against the film exchange must be taken in renting film which is furnished under an age limit?

22. Describe in detail one "Side Line for Profit."

REVIEW QUESTIONS

ON THE SUBJECT OF

ELECTRICAL PRINCIPLES

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1. What is an electrical charge in motion called?

2. Describe the simplest form of a galvanic cell.

3. On what principles are electrical currents, in general, measured?

4. What does e. m. f. mean?

5. State Ohm's Law.

6. Describe the action of a simple primary cell.

7. What is polarization in relation to primary cells?

8. Discuss the magnetic properties of a helix.

9. What is an electromagnet?

10. Make a diagram of the connections of a simple bell.

11. The resistance of a certain wire is 7.92 ohms, what is its inductance?

12. The resistance of a wire 629 feet long is .27 ohms. What is the resistance of the same wire 3,215 feet long?

13. How is the resistance of a conductor influenced by its cross-section?

14. Define *specific resistance.*

15. State the general formula for resistance calculation.

16. How is electrical conductance in metal conductors affected by temperature?

17. State the area of No. 10 B. & S. wire in circular mils and its resistance in ohms per 1,000 feet.

18. If the resistance of a certain wire is 2.3 ohms per 1,000 feet, how many feet of the wire will be required to make up a resistance of 17.8 ohms?

19. The resistance of a circuit is 1.8 ohms and the voltage is 110. What is the current?

20. Eight cells each having an e. m. f. of 9 volts and an internal resistance of 6 ohms are connected in parallel, and the external resistance of the circuit is 3.4 ohms. Find the current.

21. Which system of wiring is recommended in fireproof buildings?

22. What determines, usually, the system of wiring?

23. What is considered in locating the outlets for conductors in a building?

24. Make a sketch of an enclosed fuse.

25. How many amperes would No. 10 B. & S. rubber insulated wire safely carry?

26. What number of wire would you select for transmitting 30 amperes?

27. Sketch the series mechanism for d. c. arc lamps.

28. Describe and sketch the differential mechanism for d. c. arc lamps.

29. What B. & S. gauge number must be used for arc lamps in connection with moving pictures?

30. How many amperes will this conductor safely carry?

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